THE ENGINEERING RECORD SERIES

THE CEMENT INDUSTRY

Descriptions of Portland and Natural Cement Plants in the United States and Europe, with Notes on Materials and Processes in Portland Cement Manufacture.

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Publisher's Note.

Several years ago The Engineering Record began the publication of a series of articles upon the European Portland cement industry. The articles were prepared especially for this journal by Mr. Frederick H. Lewis, M. Am. Soc. C. E., who undertook in the interest of this inquiry a personal inspection of the important European plants, and who, on account of his familiarity with the subject, was well qualified to compare foreign with American practice. This series of papers had run through but a few chapters when it became evident that like descriptions of American plants, both for Portland and natural cements, would be of interest to a wide range of readers. Arrangements were accordingly made with Mr. Lewis and others for such articles and for contributions on processes and details of manufacture. The issues of The Engineering Record containing them being exhausted, the articles thus far printed are republished in this book in the belief that they afford for the first time a description of the cement industry as conducted at the present time in America and abroad.

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THE CEMENT INDUSTRY.

CHAPTER I.—PORTLAND CEMENT.—SKETCH OF MATERIALS AND PROCESS.

By S. B. Newberry.

Introduction.

Hydraulic cements may be divided into three general classes, as follows:

1. Portland Cement, a compound consisting essentially of lime, silica and alumina, produced by intimately mixing some form of carbonate of lime with exactly the correct proportion of clay, calcining the mixture at a high heat, and grinding the resulting clinker to fine powder.

2. Natural cement, produced by calcining at comparatively low heat a natural limestone containing usually a considerable proportion of magnesia and an excess of clay over that required for Portland cement.

3. Puzzolana, or Slag Cement, produced by mixing a natural volcanic scoria or granulated blast furnace slag, of suitable composition, with slaked lime.

The process of formation and hardening of the cement is similar in all three cases, and depends chiefly upon the formation of compounds of lime and silica which become hydrated and crystallize under the action of water. These effective constituents appear in greatest purity and most active form, however, in Portland cement, owing to the correct proportions employed and the high temperature at which the burning takes place.

If it were possible to find a bed of limestone of uniform composition and containing exactly the right amount of clay, Portland cement could be made from it by the simple operations of burning and grinding. A variation of 1 per cent. in com-

position from the correct standard, however, is sufficient to destroy or reduce greatly the value of the resulting cement. It will not be thought strange, therefore, that no such deposit of ready-mixed Portland cement material has ever been discovered. The nearest approach to such an occurrence is probably to be found in the cement rock deposits of Belgium, some parts of which, by careful sorting, judicious burning and thorough seasoning of the finished product, yield a fair, low-grade Portland. The best brands are, however, made from the same rock by grinding together the different strata in such a manner as to produce an artificial mixture of uniform and correct composition.

Most of the natural argillaceous (clay-bearing) limestones of the United States contain a high proportion of magnesia and an excess of clay, and are therefore unsuitable for Portland cement. If burned at the high temperature necessary to produce Portland, they fuse to a slag, which, on grinding, shows no hydraulic properties. Burned at a lower heat, however, only sufficient to drive off the carbonic acid, they yield a soft, yellow clinker; this, on grinding, gives the natural rock cement of commerce, of which the Milwaukee, Akron and Louisville are well-known examples.

True Portland cement, of uniform and reliable quality, can be made only from an *artificial mixture* of the raw materials.

Materials.

The necessary materials for Portland cement are: 1. Carbonate of lime, usually in the form of limestone, chalk or marl. 2. Clay or shale.

The necessary qualities of these materials may be stated as follows:

Carbonate of Lime.—This should be as pure as possible, except for the presence of clay, which, as a necessary constituent of a cement mixture, may, with advantage, be contained in considerable quantities.

Magnesia is always present to some extent, and any considerable percentage is decidedly objectionable. The Association of German Portland Cement Manufacturers has for many years fixed the maximum limit of magnesia in Portland cement at 3½ per cent. A number of manufacturers have claimed that this requirement is too severe, and that magnesia up to 5 per

cent. is harmless. A committee of the association is now making a study of this question which will require several years to complete. Meanwhile, the precise allowable limit of magnesia must remain undecided. It is, however, generally agreed that magnesia up to $3\frac{1}{2}$ per cent. is harmless, but that a somewhat larger percentage causes cement to fall off in strength and finally to crack to pieces after long periods, even after several years.

Sulphate of lime, in quantities exceeding about $2\frac{1}{2}$ per cent. is objectionable, unless a decided oxidizing flame be maintained in burning, as it is liable to be reduced to sulphide, causing the cement to turn dark blue in hardening. Such cement generally gives poor tests and produces unsightly work. This fault is more frequent with cement burned in vertical kilns than in those of the rotary type, since the former are more liable to imperfect draft and consequent reducing flame. Both magnesia and sulphate of lime are considered especially objectionable in cements that are to be exposed to the action of sea-water.

The hardness of the material is of great importance in determining its practical value, since the constituents must be ground to great fineness before mixing. The writer has found it impossible to obtain good results with pure limestone unless ground to such fineness as to pass a sieve of 150 meshes to the linear inch. Hard, pure limestone is, therefore, an undesirable material, owing to the great cost of grinding the large quantity required to the necessary impalpable powder. Limestones containing a considerable proportion of clay are much better, as they are generally softer, and, the mixing being already in part done by nature, much coarser grinding will suffice to bring about good combination in burning.

In England a comparatively soft chalk is generally used; in Germany, chalk, limestone and "mergel" (a soft limestone containing clay) are the most common materials. In the United States most of the Portland cement produced is made in the Lehigh Valley region, from an unlimited deposit of slate-like limestone containing rather more clay than is required for a correct mixture. To this a small amount of pure limestone, usually 10 to 20 per cent., is added. The grinding of the raw material is comparatively coarse, since the bulk of it is already

of nearly correct composition. In New York, Ohio and Michigan, marl, a soft, fresh-water deposit similar to chalk, is generally employed. Pure limestone is used at three or four small factories only.

The chemical composition of certain typical forms of carbonate of lime used in the manufacture of Portland cement is shown in the following table:

	Chalk, England (Reed).	Cement rock, La Salle, Ill.	Cement rock, Phillipsburg, N. J.	Cement rock, Siegfried, Pa.	Marl, Sandusky, Ohio.	Marl, Syracuse, Ind.
Calcium carbonate.	98.57	88.16	70.10	68.91	91.77	88.49
Magnesium " .	0.38	1.78	3.96	4.28	0.53	2.71
Calcium sulphate..	...	...	...	...	3.19	1.58
Silica	0.64	8.20	15.05	17.32	0.22	1.78
Alumina	0.16	1.00	9.02	7.07	1.22	0.91
Iron oxide.........	0.08	0.30	1.27	2.04	0.40	0.30

Clay—This should be highly siliceous, low in magnesia and sulphates, and practically free from sand. For convenience in securing correct proportions it is an advantage to use a clay free from carbonate of lime, though marly clays are more easily mixed with the other materials. Highly siliceous clays, up to 70 per cent. silica, or over, give mixtures which stand the high heat of the kiln without fusing, produce a clinker which is comparatively easy to grind, and yield a slow-setting cement which shows steady gain in strength over long periods. For the best results, in the writer's opinion, the silica should be equal to at least three times the iron oxide and alumina together. For example, a clay containing 18 per cent. alumina and 4 per cent. iron oxide should contain at least 66 per cent. silica. Highly aluminous clays give a fusible clinker and quick-setting cement and are in many respects troublesome to use. Clays containing more than 5 per cent. iron oxide will give a dark-colored cement, and the lower the iron, the lighter in color the cement will be.

The presence of sand may be detected by washing the clay through a fine sieve. More than perhaps 5 per cent. of sand remaining on a sieve of 150 meshes per linear inch will be likely to cause trouble unless the mixed material is subsequently finely ground.

Analyses of a few typical clays, extensively used in Portland cement manufacture, are given in the table on page 13.

By far the larger part of the Portland cement manufactured in the United States is made from natural cement rock, with-

out the use of free clay. As this rock contains the necessary clay, however, in a state of intimate mixture with the carbonate of lime present, the above principles apply to it as well as to a wholly artificial mixture.

Analyses of Typical Clays.

	Medway, Eng.	Harper, O.	Sandusky, O.	La Salle, Ill.
Silica	70.56	51.50	65.41	54.30
Alumina	14.52	13.23	16.54	19.33
Iron oxide	3.06	3.30	6.06	5.57
Lime	4.43	11.52	2.22	3.29
Magnesia	...	3.45	1.88	2.57
Carbonic acid	3.48	12.85	...	...
Alkalies	3.95	...	...	...

Alkalies (potash and soda) are not generally determined in analyzing clay. In the writer's opinion they exert but little influence, in the small amounts present in ordinary clays, on the character of the burning or quality of the resulting cement.

Proportions of Ingredients.

Much has been written concerning the chemistry of hydraulic cements, and yet the literature of the subject contains but little definite information in regard to the proportions which the chief chemical constituents should bear to each other. Vicat, early in the century, proposed the "hydraulic index," a figure representing the number of parts of silica and alumina occurring with 100 parts of lime and magnesia, to distinguish limes and cements of varying degrees of hydraulicity. Erdmenger, in 1872, pointed out that in commercial Portland cements the ratio of lime to silicates (silica, alumina and iron oxide) was, on the average, 1.9. Michaelis, at about the same time, proposed to call this ratio the "hydraulic modulus," and stated that this should lie between 1.8 and 2.2. These observations apply chiefly to the cements of a generation ago, and it is well known that with the improvement in manufacturing processes the proportion of lime in Portland cement has steadily advanced. It is also generally agreed, at present, that silica combines with very much more lime than alumina and iron oxide. The "hydraulic modulus" is therefore a variable, and must be much higher in case of siliceous materials than with those high in alumina and iron. Some formula more exact than the "hydraulic modulus," and applicable to all materials, is therefore needed.

Le Chatelier, in his masterly work on hydraulic cements, published in 1887, first gave definite expression to the relative proportions in which the chemical constituents of cements combine. He stated that the lime and magnesia in Portland cement should not exceed a maximum,

$$\frac{CaO + MgO}{SiO_2 + Al_2O_3} \leqq 3,$$

nor be less than a minimum

$$\frac{CaO + MgO}{SiO_2 - Al_2O_3 - Fe_2O_3} \geqq 3.$$

These formulas represent chemical equivalents and not weights.

The best brands of modern Portland cement approach pretty closely to the maximum formula, while one corresponding to the minimum formula would be greatly over-clayed. It is generally agreed, also, that magnesia acts in cements as an inert material, and that it should not be taken into account in calculating the composition of the mixture.

The writer's experiments,* based upon the work of Le Chatelier, have proved that the relation between lime, silica and alumina in Portland cement may be expressed by the following formula:

$$X\,(3CaO.SiO_2) + Y\,(2CaO.Al_2O_3),$$

representing the chemical composition of a correctly proportioned cement, in which X and Y are variable quantities, depending on the relative proportions of silica and alumina contained in the clay used. This formula means, simply, that for every molecule of silica contained in a cement there should be three molecules of lime, and for every molecule of alumina, two molecules of lime. Substituting weights for chemical equivalents, the above formula may be expressed as follows:

$$\text{Lime} = \text{Silica} \times 2.8 + \text{Alumina} \times 1.1.$$

This formula may be used to calculate the proportion of lime to be used with a clay of known composition, as follows:

Multiply the percentage of silica by 2.8 and the percentage of alumina by 1.1; add the products; the sum will represent the number of parts lime required for 100 parts clay.

As carbonate of lime is universally used in cement making, we may modify the above to read: *Five times the per cent. of*

* "The Constitution of Hydraulic Cements," by S. B. Newberry and W. B. Newberry, Journal Society Chemical Industry, November 30, 1897. Reprinted in "Cement and Engineering News," November, 1897.

silica, plus twice the per cent. of alumina equals the number of parts of carbonate of lime required for 100 parts clay.

If we study the analyses of the best Portland cements, we shall find that modern brands correspond closely with the above formula. Many show a slight deficiency in lime from the calculated amount. It should, however, be remembered that the formula represents the maximum of lime which can be safely used. This maximum can be reached in practice only by the most intimate mixing and thorough grinding of the raw materials. Given these conditions, the more nearly the proportion of lime approaches that called for by the formula, the higher will be the quality of the resulting cement.

As a practical example of the use of the above formula, let us suppose that we wish to make cement from a clay having the following composition:

Silica	65.4 per cent.	Lime	2.2 per cent.
Alumina	16.5 per cent.	Magnesia	1.9 per cent.
Iron oxide	6.1 per cent.	Combined water, etc.	7.9 per cent.

We now calculate as follows:

Per cent. silica $= 65.4 \times 5 =$	327.0
Per cent. alumina $= 16.5 \times 2 =$	33.0
Total	360.0

The 2.2 per cent. lime contained in the clay corresponds to 4 parts carbonate of lime. Subtracting this, we have 356 parts carbonate of lime required for 100 parts clay. From the analysis of the marl or limestone used, we may easily calculate what amount of this material will be required to give the above amount of carbonate of lime.

The writer's experiments have shown that magnesia forms with clay no products having hydraulic properties. It should therefore be disregarded in calculating cement mixtures, the composition of which should be calculated on the basis of the silica, alumina and lime only, without regard to the magnesia present. Iron oxide, also, in the quantities usually met with in ordinary clays, plays an insignificant part so far as the proportions of the constituents are concerned, and may be disregarded in the calculation.

Mixing.

The method of mixing the raw materials, as originally practiced in England, was the wet process, in which the materials

were ground and mixed in a wash-mill with a large amount of water, and subsequently allowed to settle in large reservoirs. The long time required for settling, and the cost of drying the slurry previous to burning, led to the adoption of the dry process, in which the materials are ground together in a dry state and then moistened with a little water, molded into bricks and dried. This method is largely employed in Germany and in the United States. The introduction of the process of burning in rotary kilns, now so extensively practiced in this country, made it unnecessary to form the slurry into bricks. Therefore, at the present time, dry materials are simply ground and burned in the form of dry powder, as in the Lehigh Valley region, while wet materials (marl and clay) are mixed in a plastic condition and fed direct into the kilns in the form of wet mud. There can be little doubt that a wet mixture is always more perfect than a dry one, and unless the materials are already nearly dry and more or less perfectly mixed by nature, the semi-wet process is to be preferred. Rock-crushers, followed by buhr-stones, emery mills, tube mills or Griffin mills are generally used for dry grinding of raw materials; pans with edge runners followed by tube mills are commonly employed for wet grinding. The composition of the mix must be constantly controlled by chemical tests, and the percentage of carbonate of lime kept within ½ per cent. of that found correct for the materials used.

Burning.

Four types of kiln are in use in burning Portland cement. These are: 1. Dome kilns (intermittent) similar to common lime-kilns. 2. Continuous kilns, of the Dietzsch, Shöfer or other types. 3. The Hoffman ring-kiln. 4. The rotary kiln.

The common, intermittent dome-kilns were originally the only type employed, and are still in use in Europe and to some extent in this country. Coke is used as fuel, and the consumption amounts to about 25 per cent. of the weight of clinker produced.

Continuous kilns, of the Dietzsch or Shöfer type, are costly to construct, and require skilled labor for their operation. They are, however, very economical of fuel, using soft coal to an amount not exceeding 12 per cent. of the weight of clinker produced. They are to some extent used in Europe and this country.

The Hoffman ring kiln also uses soft coal, and is very eco-

nomical of fuel. It is largely used in Europe for cement burning, but has not been adopted for this purpose in this country.

These three types of kiln all require that the material should be charged into them in the form of dry bricks or blocks. The cost of molding the slurry into the necessary forms, drying the bricks on wagons in drying tunnels, and handling them to the kilns, is very great, and with our expensive labor would undoubtedly have prevented any considerable development of the Portland cement industry in this country, if a method of avoiding these expensive operations had not been discovered.

The rotary kiln is fully described in another part of this volume. In its essential features it was patented by Siemens in 1869, and, in combination with a gas burner and other appliances, by Ransome in 1885. It was not found successful for cement-burning in England, but has been improved and developed by American engineers to such a point that over 70 per cent. of the Portland cement made in this country is now burned in rotary kilns, while in quality the product is at least equal to that of older forms of apparatus.

The modern rotary cement kiln consists of a slightly inclined steel cylinder, usually about 60 feet in length and 6 to 7 feet in diameter, lined with fire-brick, and revolving on rollers at the rate of one revolution in from one to three minutes. Fuel oil was formerly used as a source of heat; now, powdered coal is generally employed. The cement material is fed in continuously, in the form of liquid mud or dry powder, at the upper end. Descending gradually, it parts with its water (if present) in the upper third of the kiln, becomes heated to redness, loses its carbonic acid, forms little rounded balls which reach a nearly white heat in the lower third of the kiln, and finally issue as well-burned, black clinker in grains of about pea-size, at the lower end. The operation is a continuous one, and with proper care all under or over-burning may be avoided. The saving in labor resulting from the use of the rotary kiln is very great. The fuel cost is, however, very high, amounting to a consumption of soft coal equal to 50 per cent. of the weight of clinker in the case of wet slurry, and 40 per cent., with dry materials. Methods of utilizing a large part of the heat now wasted will undoubtedly be devised, and the present extravagant fuel consumption will probably be considerably reduced. It is not likely, however, from

the nature of the case, that the rotary kiln will ever equal the continuous vertical kilns in fuel economy.

In the conversion of the mixture of carbonate of lime and clay into cement clinker, the changes which take place are, according to Le Chatelier, the following: At a red heat the combined water is expelled from the clay; at a somewhat higher temperature the carbonate of lime is decomposed, and the carbonic acid escapes. The silica and alumina of the clay immediately enter into combination with the lime, forming calcium silicates and aluminates. First, fusible glasses, rich in silica, are formed; these gradually become more and more basic by combination with more lime, until at last the all-important calcium tri-silicate is produced. The iron and alumina also remain in combination with lime as an alumino-ferrite.

A peculiar phenomenon is observed if the white-hot clinker is suddenly cooled by allowing it to fall into water. In this case it shows a pale yellow-ochre color, instead of the greenish-black color of clinker gradually cooled, and on drying and grinding it yields a yellow cement of normal hardening properties. If, however, the clinker is allowed to cool for a few seconds to a red heat, and is then thrown into water, it shows its ordinary dark color. It is evident that during the first few moments of cooling, some change, not yet explained, takes place in the state of combination of the iron.

The proper degree of burning is indicated by the formation of a dense greenish-black clinker. Light-burned clinker is brownish and soft, while over-burned clinker is fused and slag-like, often showing a light brown color on the inside of the lumps. Long-continued burning or excess of clay causes the clinker to "dust" or fall to powder on cooling, the resulting powder showing little or no hydraulic properties. This defect is much more common with vertical than with rotary kilns. There can be no doubt that the quick burning and rapid cooling of the latter process is most beneficial to the cement, since the process is promptly arrested when the product has reached its greatest excellence.

Under-burned cement is often yellowish or brownish in color, and is apt to be quick setting and to expand and crack in hardening. Over-burned cement is usually slow in setting and hardening, though it may show excellent tests at long periods. Cement

which is correctly proportioned, perfectly mixed, and well burned, does not begin to set until two hours or more after mixing with water, but hardens sharply and rapidly after the setting begins, and shows a steady gain in strength, especially when tested with sand, up to several years. It is an almost universal practice to add from 1 to 2 per cent. of ground gypsum to cement to slow the setting. If this amount is not exceeded, the addition is beneficial to the cement, and no bad effects have been observed.

Grinding.

Portland cement clinker was formerly ground with buhr-stones and bolted through revolving screens. At present the Griffin mill, or the German ball-mill followed by the tube-mill, are almost universally used. A fineness of 92 to 93 per cent. passing a No. 100 sieve is generally attained in American practice. Finer grinding is rarely demanded by the trade, but can easily be accomplished if necessary. There is, of course, a point beyond which it is not economical to carry the fine pulverizing of cement, since the same result can be accomplished by using slightly richer mixtures on the work. What this point is must be determined by experience. At present, the public is ignorant of the proper methods of using very finely ground cement, and the manufacturer who puts such material on the market is more likely to receive blame than praise.

As to the quality of the Portland cement now produced in this country, no better testimonial can be found than that given in the reports of Mr. Richard L. Humphrey, included in the reports of the Mayor of Philadelphia for the years 1897 to 1899. Tables showing the results given by all cements tested at the Philadelphia City Laboratory show that the average of all American cements is distinctly higher than that of the English or German. This evidence, with numerous similar records obtained by Government and private engineers, warrant the claim that there are to-day no Portland cements made in any foreign country that are equal to the product of the leading American factories.

CHAPTER II.—THE PORTLAND CEMENT PLANT OF THE COPLAY CEMENT COMPANY, COPLAY, PA.

By Frederick H. Lewis, M. Am. Soc. C. E.

Both the new and the old plants of the Coplay Cement Company are located on the west side of the Lehigh River and immediately alongside the Lehigh Valley Railroad, near Coplay station, Lehigh County, Pa. At this point the late D. O. Saylor and Esaias Rehrig, the first president and treasurer respectively of the cement company, began the manufacture of hydraulic cement 30 years ago. This was not even then an entirely new industry in the locality. The discovery that the limestone formation thereabouts possessed hydraulic properties had been made at the time the Lehigh Canal was built, and there had existed afterward a small manufactory of cement at Siegfrieds Bridge, on the east side of the river, opposite Coplay. Nor was the manufacture of calcareous cement in any sense a novelty elsewhere in the United States. The Rosendale cement of New York had been on the market for over 30 years, and manufactories were already in operation on the Potomac, the James and the Ohio River valleys.

The particular interest which attaches to Mr. Saylor's and Mr. Rehrig's work, and to that of their successors, arises from the fact that they very soon discovered the possibility of making Portland cement from the raw materials at their disposal, and that they were the pioneers in America in this industry, which at the present moment is undergoing such an extraordinary development in the Lehigh Valley. Of natural rock cements in 1867 there were a number, but of Portland cements there were none in America prior to the Saylor's brand.

As the two products may not be clearly distinguished in the minds of all readers of The Engineering Record, it may not be amiss to briefly define them. The natural rock cements, variously known as Rosendale cements, natural cements, Roman cements and hydraulic limes, are made simply by driving off the

carbonic acid from argillaceous limestones. This is done at the low temperature of an ordinary limekiln, say from 1,000 to 1,200 degrees Fahrenheit. The soft yellow stone which is thus obtained is then ground to powder, and this constitutes the finished product. Portland cement, on the other hand, according to recent European specifications, "shall be produced by the grinding of scorified clinker obtained by the calcination to incipient vitrification of an intimate mixture of carbonate of lime and of clay accurately proportioned, chemically and physically homogeneous in all its parts." The distinction is that in making Portland cement there is an artificial mixture of the raw materials, a calcination at a temperature above 2,000 degrees Fahrenheit, and that purer raw materials are used than are necessary for natural cements.

It is evident that Messrs. Saylor and Rehrig had scarcely begun the manufacture of natural rock cement at Coplay before they became interested in the Portland cement industry, then rapidly extending as a European manufacture. Within five years they had apparently acquainted themselves with the conditions and methods of the Portland process, and were satisfied that the Lehigh deposits, though wholly different from those commonly used in Europe, were yet suitable and of sufficient purity for this manufacture. This latter distinction, sufficient purity, be it understood, is most important, for of all the argillaceous limestone deposits from which natural cements have been made in America none save the Lehigh Valley deposits in Pennsylvania and New Jersey have as yet been proved suitable for Portland cement. In 1872 practical experiments were begun, and in 1876 the Saylor's brand of Portland cement was on an established footing and received a medal at the Centennial Exposition. It also received a medal from the World's Columbian Exposition in 1893. The Pennsylvania Geological Survey's report of 1878 records that the works then had seven kilns for Portland cement, designed by James Hubett of London, producing an output of 2,500 barrels per month. The works were enlarged from time to time on the lines of English practice, employing bottle section intermittent kilns, until 1893, when a continuous kiln of the Danish pattern was built for purposes of experiment. As a result of this a new plant has been built and is now in full operation. It is this plant which is illus-

trated and described below. Its general plan is shown in Figure 1.

The writer is indebted to the courtesy of Mr. Charles M. Saeger, manager of the Coplay Cement Company, for data from which the following description was prepared, and for blue-prints from which the cuts have been made.

The raw materials of the Coplay Company are the hard limestones found at the top of the great Silurian limestone deposit known as Formation No. 2 of the Pennsylvania Geological Survey. At Coplay the upper beds of this formation, which in

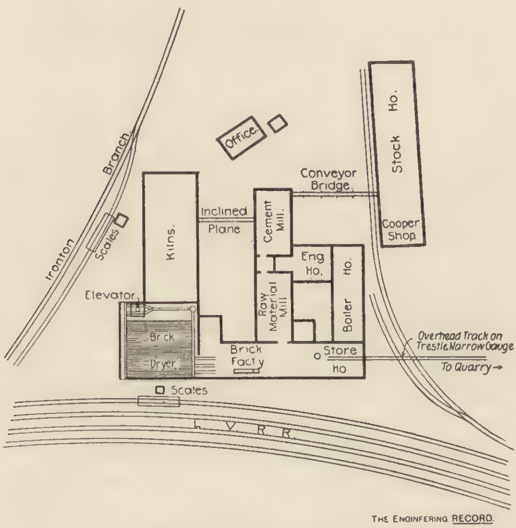


Figure 1.—General Plan.

Pennsylvania is reckoned to comprise a series of strata over 6,000 feet thick, passes under the Hudson River slate formation (No. 3), and it is here, directly below the slate, that the water lime rock is found. To the southeast, toward Allentown, the rocks and limestones are unfit for cement making. To the northwest, toward Slatington, shales and slates are everywhere found, but at the junction of the two formations is found for a considerable depth the cement rock, dark in color, nearly black, close grained and slaty in appearance. It is simply a natural mixture of carbonate of lime and of clay in proportions approximating those required for Portland cement mixture.

Figure 2 is a view of the quarry from which this cement rock is taken, and clearly shows the method of working. There is quite a little variation in the composition of the rock in different strata, and frequent changes are required in the proportions of a "mixture." This it is the duty of the chemist to determine several times daily, and the proportions are worked out by precisely similar methods to those which are used abroad for wholly different raw materials—the soft chalks and clays of Northern Europe. Now, in Lehigh County limestones are abundant and are quite similar in appearance, in hardness and in weight to the cement rock. At Coplay such limestone beds are found just below the cement rock, geologically speaking, hence the natural development of manufacture has been to add these limestones to a "low" cement rock rather than to add clay to a "high" cement rock. In quarrying cement stone it is thus the practice to work the beds which contain less than the normal quantity of lime and to complete the mixture by adding limestone. Thus, if it is desired to make a mixture containing 74 per cent. of carbonate of lime with 26 per cent. of clay, organic matter, etc., this will be done by mixing, let us say, 80 per cent. of cement rock analyzing 70 per cent. carbonate of lime with 20 per cent. of limestone analyzing 90 per cent. carbonate.

The general features of the new plant are illustrated in Figures 1 to 11. The general plan is shown in Figure 1. The plant is designed for a capacity of 500 barrels of cement per day, is substantially built and thoroughly modern in all its appointments. The kiln and mill buildings and the engine and boiler houses are constructed of iron, brick and concrete throughout, and are as nearly fireproof as buildings can be.

The preparation of raw material has three purposes in view, to wit: First, to incorporate two raw materials so as to produce a thoroughly homogeneous mixture in a fine state of division, so that chemical action between the particles can take place; second, to make up this mixture into lumps or balls suitable for charging into a furnace or kiln; and, third, to dry these balls or bricks, so that when placed in the kilns they will be practically free from moisture—"bone dry."

In practice at the Coplay plant the two grades of stone are run into the works on an overhead track entering under the

Figure 2.—View of the New Quarry.

roof of the raw material mill, a T-shaped building, as shown on the general plan, Figure 1. On the ground floor of the nearer wing of this building are bins for the rock, the crushing and cracking machinery, and a brick machine. In the further wing are 16 run of millstones. Overhead in both wings are the hoppers and bins, to which the raw material is carried by conveyors when passing from one machine to another, and a pug mill for mixing and wetting the ground rock before it passes to the brick machine. The crushers and crackers are of the coffee-mill pattern. The mills are of the best European type of millstones, the lower stones being driven as shown in Figure 3.

The cement rock is dumped from the overhead track into a bin at one side of the raw-material mill and the limestone into a bin at the other, and the two ingredients, quite similar in

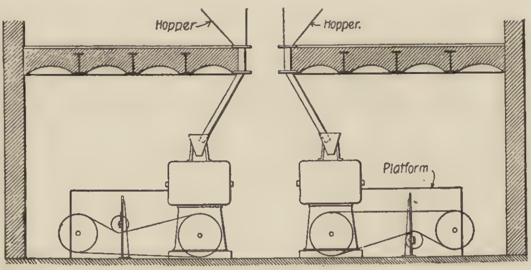


Figure 3.—Mill for Grinding Raw Material.

general appearance, are thus ready at hand for mixing in any proportions they may be required. To perfect the mixture of the raw materials, the first step mentioned above, the crackers and millstones are the means employed. At Coplay the mixing of these two rocks takes place just before the rock goes to the millstones. Limestone and cement pass separately through the crusher and crackers to separate hoppers. The largest pieces of stone are then not bigger than a grain of corn. Just under the hoppers automatic scales are placed, and on these the materials drawn from the two hoppers are weighed side by side in quite small units and discharged together into the conveyor leading to the millstones. The mixing and kneading of the mass then goes on in the conveyors, in the millstones, and in the pug mill and brick machine.

One precaution is necessary in order to make the bricks, the

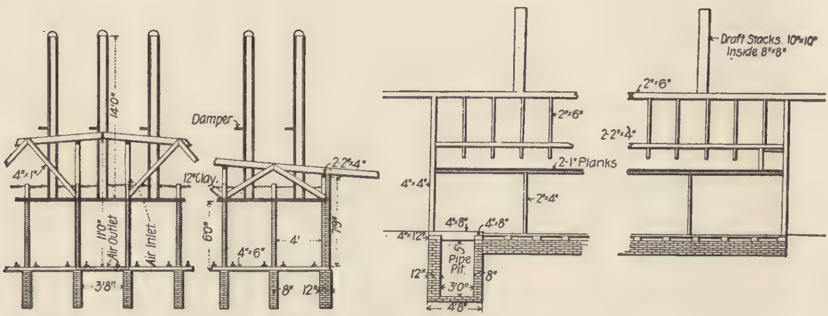


Figure 4.—Sections of the Tunnel Dryers.

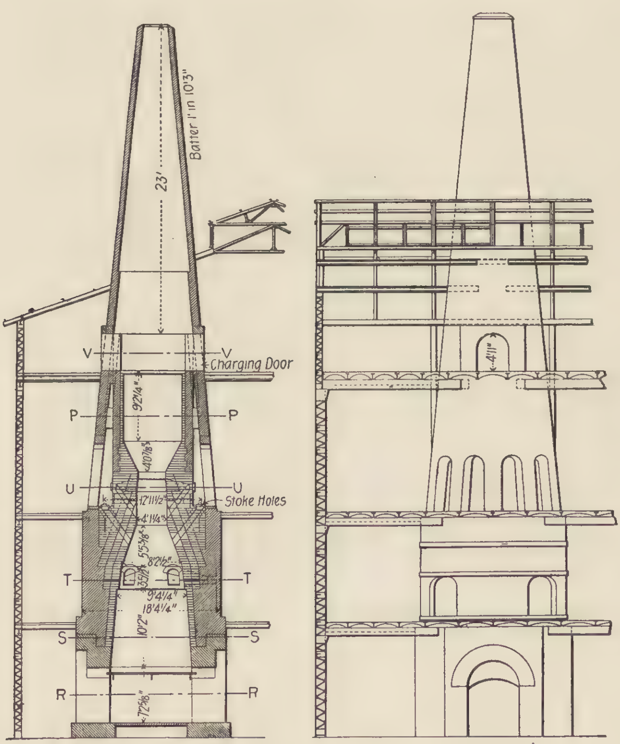


Figure 5.—The Continuous Kiln.

second step in preparing raw material, in dealing with Coplay rocks. It will readily be understood that even when reduced to a fine powder such raw material lacks plasticity—it will not mould well nor stick together. It is necessary to remedy this, and that is accomplished by regularly adding to the crusher a percentage of natural cement from nearby kilns producing that grade of material. This gives the necessary plasticity to the pug mill and acts as a binder for the bricks. For brick-making an ordinary screw mill is used, the stream of slurry issuing from it being cut into bricks by wire cutters. One brick mill does all the work.

To the left of the raw-material building are the tunnel dryers, comprising 17 tunnels 75 feet long. These are steam dryers, each tunnel being fitted with 30 1-inch steampipes running along the bottom, and with ventilating hoods in the top. There are also cold air ducts leading from the roof to the bottom of the tunnels to provide a circulation of air. The tunnels have a fall of 18 inches in their length, so that all water condensed in the pipes will collect in a main at the further end, from which it is pumped back to the boilers. The general construction of the tunnels is shown in Figure 4. The cars with wet bricks are charged in the tunnels at one end and are drawn from the other, a continuous operation. At the drawing end of the tunnels there is a track leading to an elevator reaching the upper or charging floor of the kiln building.

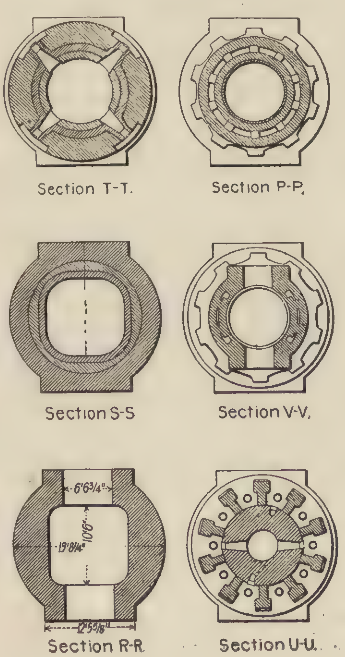


Figure 6.—Sections of the Kiln.

The kilns are shown in elevation and section in Figures 5 and 6. They are continuous; that is, the charging at the top and drawing at the bottom goes on day and night for months, as in an iron furnace, until it becomes necessary to draw the fires for

relining or other serious cause. They are of the Shoefer type, a modification perfected in Denmark of the well-known Dietzsch kiln, used in Germany. The dried slurry is charged through doors shown on the upper floor level, and the kiln is constantly

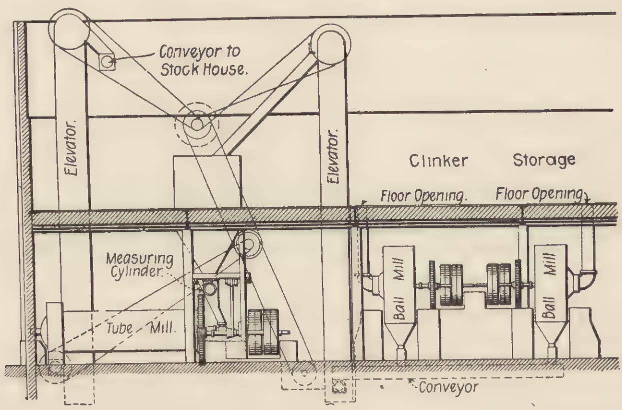


Figure 8.—Section W-W of the Cement Mill.

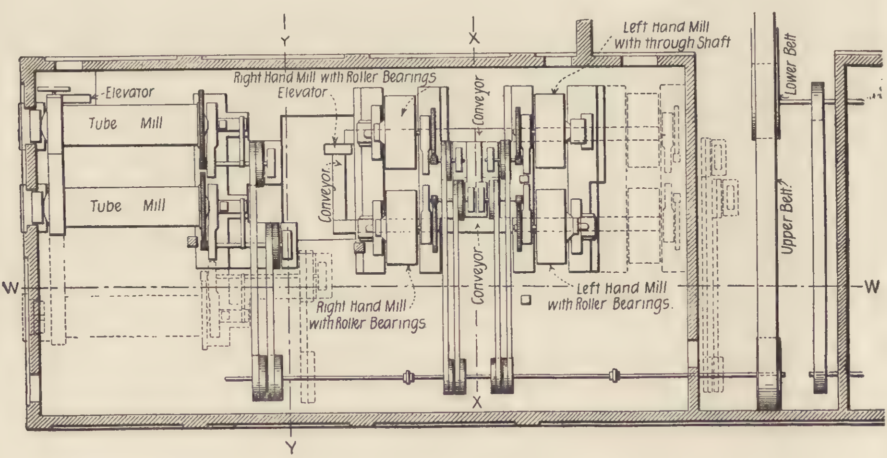


Figure 7.—Plan of the Cement Mill.

kept full up to this point. The fuel is introduced through stoke-holes on the floor below. The principle of the kiln is quite the same as in the Dietzsch kilns. There is a long vertical shaft, the upper part of which serves as a pre-heater for the bricks;

a narrow middle section, which is the combustion chamber, or crucible, and a lower section, which serves to cool the clinker and heat the draught. The kilns are thus economical in fuel from the fact that all the heat is utilized. The draft of air

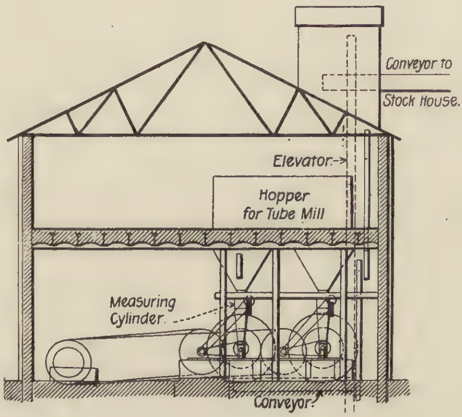


Figure 9.—Section Y-Y of the Cement Mill.

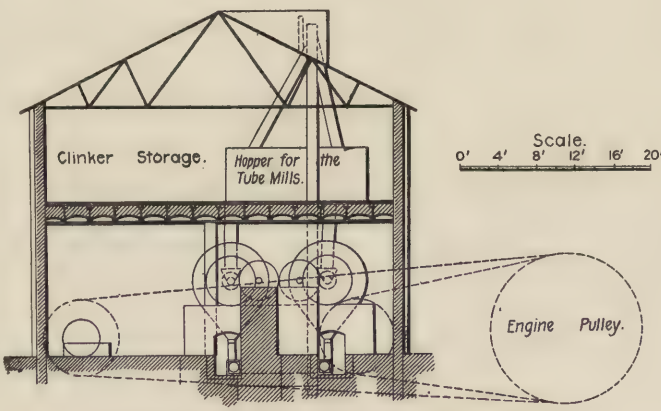


Figure 10.—Section X-X of the Cement Mill.

from below is heated by passing over hot clinker before it reaches the combustion chamber, while the products of combustion heat the bricks to a high temperature before they reach the fire. The temperature in the shaft at the charging door

above is quite low; the clinker arrives at the grate below nearly cold. The plant now has nine of these kilns (one at the old works) and two more are in course of construction. Gas coal is used for fuel. The drawings and right to use the kilns were furnished by Messrs. F. L. Smidth & Company, of New York City, who also supplied the ball and tube mills.

The bottom of the kiln is filled with grate bars at a height of 6 feet above the lower floor, and the burnt clinker is withdrawn from the corners of the kilns at regular intervals into wagons, the contents of which are weighed. The loaded wagons are drawn up an incline by a cable to the second floor of the cement mill. There is ample floor space here to store a large quantity of clinker to be drawn upon as needed for the mills, where the finishing process, that of grinding, goes on.

The mills for grinding clinker are shown very clearly in Figures 7, 8, 9 and 10. All the clinker passes successively through the ball mills and the tube mills. The ball or "kugel" mill is a German machine, consisting essentially of a revolving drum containing a large number of steel balls. The clinker enters through a hollow shaft, and is ground as the drum revolves by the impact and abrasion of the balls. There are openings in the drum through which the clinker falls on the wire screens, and thus passes out below as the particles become sufficiently reduced. There are four kugel mills, with room provided for two more. The material issuing from the kugel mills is carried by a conveyor to hoppers above, discharging to the tube mills. The tube mills are of Danish manufacture, and are long, horizontal tubes turning on central shafts. The material is forced in through a hollow shaft by means of a worm conveyor, and the feed is readily regulated by an ingenious device set in the base of the hopper above this conveyor. Four cups are cast in the face of the revolving drum. The cups fill as they pass under the mouth of the hopper and empty as the drum revolves. The speed of revolution regulates the discharge from the hopper. The grinding in the tube is done by the impact of flint balls in quite the same way as the kugel mill effected the first reduction. The cement issues from slits in the tube at the opposite side from which the material enters. Very fine grinding is effected by these mills. There are two tube mills, and space is provided for a third. The grinding plant has evident advan-

tages, because, from the simplicity of the means by which the reduction is effected, repairs are reduced to a minimum. The stock house is of concrete of monolithic construction, and is shown by Figure 11.

The finished product of the cement mill is carried to the storehouse by a belt conveyor, running upon a bridge at a high line from the top of the mill to the upper part of the stock house. In the stock house it is distributed to the bins by worm conveyors in the usual manner. The northern end of the stock-house building serves as a cooper shop.

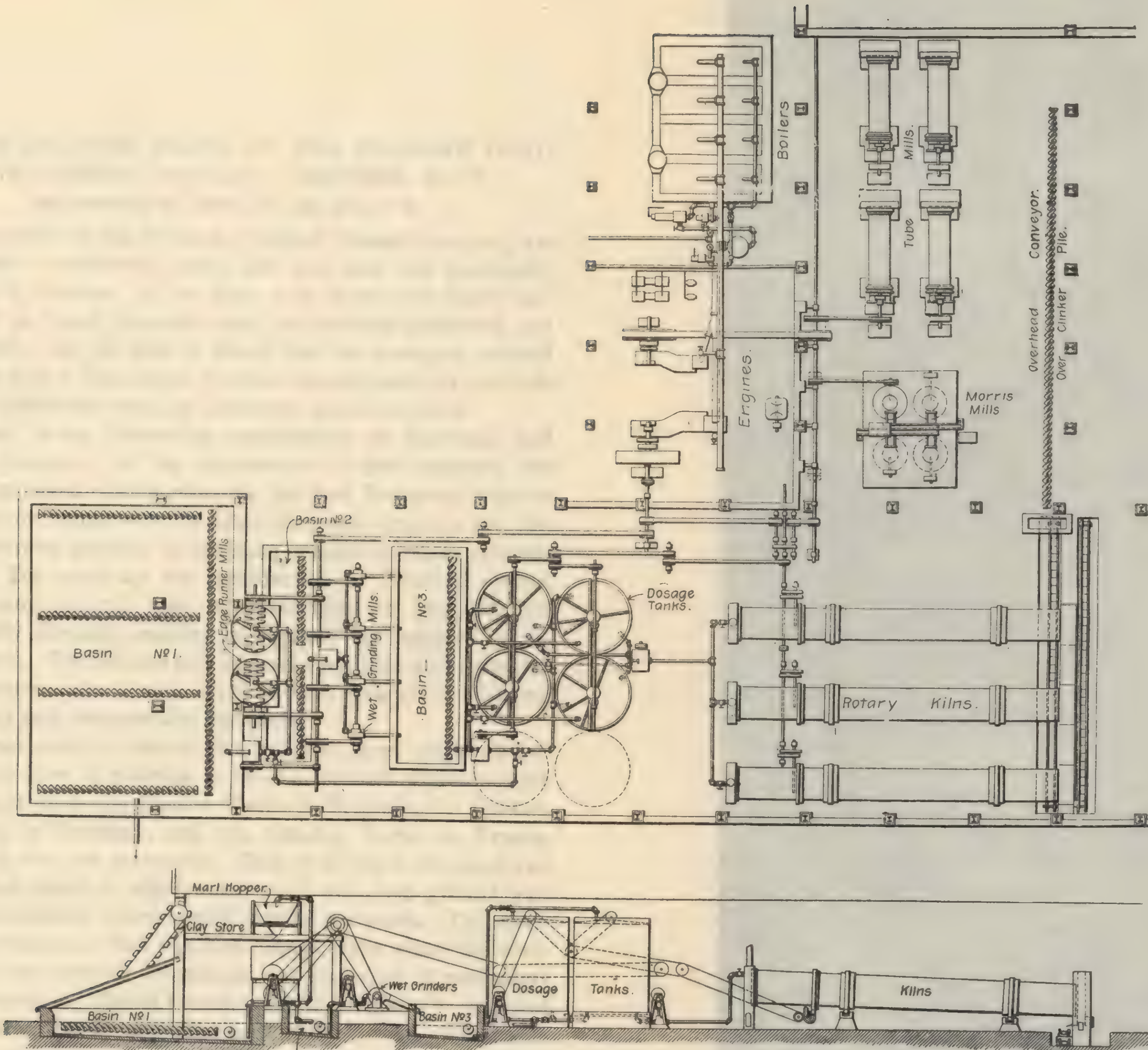
Both the cement and raw-material mills are driven by the same engine, driving two shafts by belts directly from the fly-wheel. The main driving pulleys are set in a belt drive between

Figure 11.—Concrete Stock House.

the two mills, separated from them by brick walls. Figure 7 shows this arrangement, and the line of shafting into the cement mill. The raw-material mill is to the right, and the two lines of shafting entering it are indicated. Steam is furnished by a battery of four Stirling water-tube boilers of 900 horse-power. The engine is of the cross-compound condensing type, and is of 700 horse-power. It was built by the Buckeye Engine Company, of Salem, O. A broad belt on the fly-wheel drives the nearer line of shafting, and a narrow belt running on top of the other, or tandem, drives the further shaft. The whole installation of power plant, transmission and milling machinery is admirable.

The works are provided with a laboratory for the quick determination of the chemical composition of the rock and mixtures, and with a physical laboratory for determining the pureness and strength of the cement. The laboratories are in charge of Mr. George S. Saylor.

It will be observed that this fine plant of the Coplay Cement Company, thus illustrated and described, is equipped for the most part with those structures and appliances developed by European experience which the company's officials have considered most suitable for American conditions.



Figures 15 and 16.—The New Plant of the Bronson Portland Cement Company, Bronson, Mich.

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CHAPTER III.—THE PLANT OF THE BRONSON PORTLAND CEMENT COMPANY, BRONSON, MICH.

By Frederick H. Lewis, M. Am. Soc. C. E.

The new plant of the Bronson Portland Cement Company was placed under construction early last year and was practically completed in October. It has since been thoroughly tried, supplemented as found desirable and its methods perfected and standardized. On the first of March last its managers entered the market with a high-grade Portland cement made by methods which are distinctly novel in American manufacturing.

The plant is an interesting combination of European and American practice. In the preparation of raw materials the methods employed closely resemble the best European practice by the wet or humid way; in kilns the plant employs the distinctly American practice of calcining cement in rotary cylinder furnaces. Ten years ago the manufacture of Portland cement on these same general lines was attempted in England, but failed chiefly through inability to regulate the regimen of rotary furnaces. The scheme now appears simplified and corrected in an American plant, with every present indication of being productively and commercially successful.

In the raw-material side of this mill the plant employed follows exactly lines of practice to be seen in such representative European plants as the Condor Works in Belgium, the Dyckerhoff Works in Germany, and the Candlot Works in France, dealing with wet raw materials. Thus at Bronson the marl and clay are first mixed in edge-runner mills and then ground wet. This is Dyckerhoff's practice with similar materials. The mixture thus perfected is then run into dosage tanks where the composition of the slurry is determined and corrected (if necessary) before calcination. This is French practice as regularly employed in the Candlot, Condor and other new plants abroad. The whole scheme is obviously correct and rational, and indeed has never lacked theoretical recognition. Everyone agrees that the finer and more homogeneous the mixture of raw materials, the better the cement. Everyone, too, admits that if the mixture is not

normal, the time to find it out and correct it is before calcination. But this is theory, and, in successful manufacturing enterprises, commercial considerations must always limit theoretical ones. It is much to the credit of Mr. C. B. Stowe, the manager of the Bronson works, that he has been able to realize these ideas on a commercial basis under American conditions of manufacture. The details will appear more fully below.

In kiln practice the Bronson plant marks also an interesting evolution. As noted above, the rotary cylinder furnace was tried in England about 1888 and failed. A year later it was introduced into America by the Atlas Cement Company on the hard, dry raw materials of the Lehigh Valley, and was presently brought to a commercial success there on this class of material. In 1893 rotary furnaces were installed on wet raw materials at Warners, N. Y., but through an unfortunate combination of practical difficulties and commercial stringency, the enterprise was not successful. In the same year a quite similar plant of rotary furnaces was installed on wet raw materials at Sandusky, O., and it developed at first several practical difficulties. In these plants it was considered necessary to dry the wet raw materials before they entered the kilns. This practice was presently modified at Sandusky so as to prepare the raw materials by the semi-humid way, and introduce the slurry into the kilns without drying it. This gave much more satisfactory results. Now at Bronson the preparation of raw materials is by the regular wet way and the slurry containing from 50 to 60 per cent. of water is introduced directly into the kilns by a pump. This is evidently the last step in simplification of process and proves to be not only the simplest method, but the one which presents the least practical difficulties.

For the reasons set forth above, the Bronson plant possesses an unique interest in cement manufacturing at the present time. It offers new possibilities in manufacture by the wet way here; and in Europe, where the wet way is so generally employed, it will at once suggest the practicability of substituting the American rotary kiln with its large output for the various types of shaft furnaces now in use there.

Raw Materials and the Wet Mill.

The raw materials of the Bronson plant are soft wet marl and shaly blue clay. The works are built adjacent to the main

line of the Lake Shore & Michigan Southern Railway, on a tract of some 500 acres of land owned by the company. The land is low and wet. The top soil for some 3 feet in thickness is peat, which is said to be of excellent quality, burning with very little ash. Below this is the bed of marl, which is estimated to have a maximum thickness of 30 feet, with an average of 20 feet over the entire property. Its general analysis as reported by Mr. C. J. Wheeler, chemist of the company, is as follows:

	Per cent.
Carbonate of lime	86.00
Clays (silica, alumina and iron oxide)	4.00
Organic matter	10.00
	100.00

The magnesia and sulphur are in very small proportions. As dug from the ground, this marl contains about 40 per cent. solids and 60 per cent. of water. It is not a shell marl, but is amorphous. It has probably been deposited through many centuries from water holding lime in solution from springs. Being deposited thus by evaporation over a large area of sluggish water and never having been above water to allow it to dry out and crystallize, it is now found in a soft, amorphous condition and of an unusually fine texture. It is reported to be so fine that without any preliminary preparation over 90 per cent. can be washed through a 200-mesh sieve. Thus in analysis and in physical properties this marl is excellent for cement manufacture.

The clay is mined some two miles distant, adjacent to the Lake Shore & Michigan Southern Railway. The surface clays not being found satisfactory, a shaft some 45 or 50 feet deep has been dug, and the clay is mined by a system of headings and galleries. At this depth excellent clay, free from sand and of fine texture, is found. The general analysis as reported by Mr. Wheeler is as follows:

	Per cent.		Per cent.
Silica	62.00	Magnesia	1.00
Alumina	20.00	Sulphuric acid	0.50
Iron oxide	8.00	Organic matter	8.00
Lime	0.50		
Total			100.00

It is estimated that the clay is mined and delivered by con-

tractors at a cost not to materially exceed that of excavating and handling it 1,000 feet from the mills.

A general view of the works as they now are is shown in Figure 12, the plane of the picture being parallel with the Lake Shore & Michigan Southern Railway, which is a few rods distant. The picture shows the office and laboratory building on the left and the cement mill to the right, viewing it from the stock-house end. The building has a steel frame throughout. All parts of the plant, indeed, except the stock bins, are built of concrete and steel, making a substantial and nearly fireproof construction. There are two sidings from the railroad,

Figure 12.—View of Works.

as shown in Figure 12, the first bringing in general supplies to the side of the mill, and the other being used to bring in clay which comes in by rail. Figure 13 is a picture of the barge and Marion steam shovel, which completes the last general feature of the plant.

In the regular operation of the plant the steam shovel dredge mounted on a 25x50-foot barge strips off the 3 feet of surface peat and deposits it in the excavation from which the marl has already been taken, excepting such quantity as is required to build an embankment alongside for the pump car. The dredge excavates the marl below to the amount of 600 cubic yards in

10 hours, and makes a channel which fills with ground water and floats the dredge as it moves forward into the excavation. The marl is deposited in the hopper of a pug mill, which chops it up and mixes it with water from a small pump on the dredge. The mixture is then discharged to the sump of a pump, which delivers it by a pipe line to the large basin No. 1 of the mill, shown in general plan, Figure 15. This basin or vat is a concrete lined pool of large capacity on the ground floor of the mill. The pug mill and conveyor pump are mounted on a platform car carried on an 8-foot track alongside the dredged channel. Between the rails of this 8-foot track is a narrow gauge

Figure 13.—Barge and Steam Shovel.

track, on which several 2-yard dump cars are stationed, ready to carry marl to the mill in case of any failure of the pump. The clay is delivered by dump cars, discharging from a trestle at the side of the mill.

A general ground plan of the mill is given in Figure 15, and a section through the raw material or wet side of it, and an elevation of the furnaces in Figure 16. On these figures three basins or pools appear, marked respectively 1, 2 and 3. Basin No. 1 is quite large and is used to receive and store marl pumped in continuously from the dredge. Basins Nos. 2 and 3 are used simply to receive the slurry as it passes from one mixing appa-

ratus to another. Over basin No. 1 is a platform on which the clay is received as brought in from an outdoor pile by conveyors. Adjacent to the three basins are the three sets of machines used for mixing and grinding the composition of marl and clay. These machines are the edge-runner mills, the wet-grinding mills, and the steel dosage tanks. Then there are four pumps for handling the slurry from the basins to the machines and from the dosage tanks to the kilns. All this side of the mill gets power from a 300-horse-power Buckeye engine, shown in plan on Figure 15, with full detail of the drive from it. It will be observed that this engine also runs a counter shaft from which the three kilns can be revolved if desired, and that similarly the stirring shafts

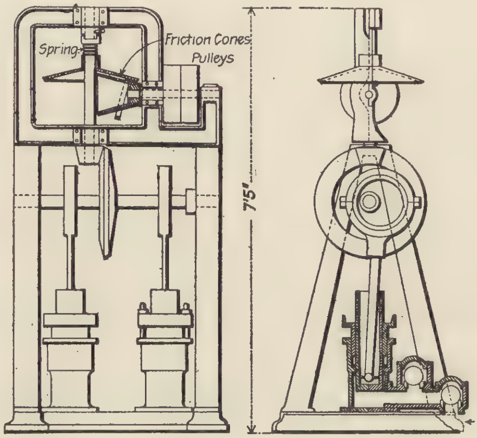

Figure 14.—Special Pump for Soft Material.

in the dosage tanks can be run from another engine set to run the finished material or "dry" side of the mill. Thus the turning of the kilns and the stirring of slurry in the dosage tanks can be done with either engine, and either side of the mill can thus be shut down without interfering with the continuous operation of the kilns. As the kilns run day and night, while the rest of the plant runs normally but 10 hours a day, the advantage of this arrangement is evident.

In regular operation of the wet side of the mill the clay, in weighed proportions, is dropped by chutes from the receiving floor into the edge runner mills, of which there are two. Marl

in normal proportion is then pumped from basin No. 1 into hoppers above the mills, and is discharged upon the clay by opening valves in the bottom of the hoppers. The mixing and grinding of marl and clay by the molars of the mills then proceeds for a regular period for each charge, at the end of which the contents of the mill is discharged through a valve in the bottom into basin No. 2. This basin has a capacity of about 500 barrels of slurry. A pump draws the slurry continuously from basin No. 2, and discharges it through four wet-grinding mills set up just in front. These mills consist of iron disks revolving against each other, the slurry being fed in through a hollow shaft. Each mill grinds 300 barrels of slurry in 10 hours, discharging continuously into basin No. 3. This completes the grinding of raw materials. The drawing (Figure 15) shows screw conveyors in the three basins. These are merely to keep the mass of slurry agitated and move it in the direction of the pumps. The basins are also inclined toward the pumps.

The large steel dosage tanks into which the slurry is pumped continuously from basin No. 3 are for storing slurry for the kilns, and for holding it while its composition is being determined in the laboratory. If the analysis of the slurry is not normal, the mixture can be corrected by additions of marl or of clay as may be required. The four tanks hold enough slurry to make 1,000 barrels of cement. In regular operation the idea is to empty completely basins Nos. 2 and 3 at the close of each day turn, and to have the dosage tanks stocked full of slurry ready for the kilns. Each of the four tanks has a central vertical shaft, carrying a series of arbors at different heights. The continuous revolution of these arbors prevents the slurry from settling and from caking on the bottom. Two more tanks are to be built so as to still further increase the stock of slurry which may be carried.

Kiln Practice.

The arrangement of the kilns in plan and elevation is shown in Figures 15 and 16. In Figure 17 there is an elevation showing in detail the mounting of the kiln, and two sections showing the bearings, the lining of the kiln, etc. Mr. C. B. Stowe, the general manager and engineer of the company, has, in building these kilns, devoted much attention to the mechanical details, and to the linings. The kilns are 60 feet long and 6 feet in

external diameter. They are mounted on double roller bearings at each side, or have four bearing wheels at each end. There are also roller thrust bearings parallel with the axis of the cylinders. The kilns are revolved by pinions engaging outside circular racks. As before noted, the kilns can be turned by either of the two engines constituting the power plant of the mill by means of friction clutches on counter shafts geared to the driving shaft of the furnaces. The speed of revolution can also be made either one or two revolutions per minute by shifting friction clutches on the counter shafts driving each kiln. This change of speed is under control of the burner, and can be varied to suit the temperature of the kiln. As one of these great cylinders with its lining and charge weighs something like 100,000 pounds, and as its successful operation depends entirely on its

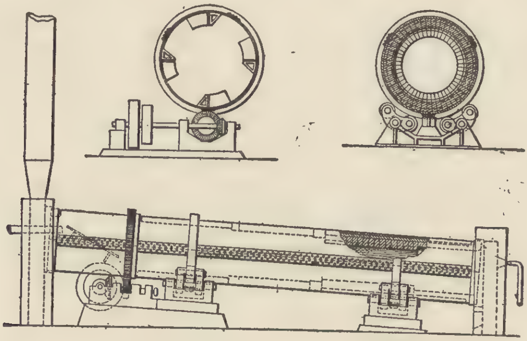

Figure 17.—Details of Kiln.

regular working day and night, it is important that the carrying and turning mechanism should be the best.

The lining of the kilns is a graduated lining, varying in thickness with the temperature to which it is subjected at different points. The extreme upper end is not lined at all, while there is a maximum thickness at the point of highest temperature some yards above the lower end. This arrangement not only holds the heat of the furnace better than in the old practice of uniform lining, but promises to give the kilns a longer life before relining is necessary. With a uniform lining the heat radiated from the lower section of the kiln is excessive, and this is bad for kilns and bearings. All bricks in the kilns are arch

bricks, fitting accurately to the radius required. The fuel is crude petroleum, delivered from three jets under an air pressure of 8 or 10 pounds. All three burners and the air pipes are under control of the burner in charge of the kiln.

In regular operation the wet slurry, containing from 50 per cent. to 60 per cent. of water, is delivered into the upper ends of the kilns by a pump drawing from the dosage tanks. This liquid slurry, of the consistency of paste, falls on inclined wing plates riveted to the shell of the furnace. These plates lift it up and turn it over. It dries as it slowly descends and as it is carried forward through the first 20 feet by the rotation of the kiln. As the temperature rises in the next 20 feet the carbonic acid is expelled; while in the last 20 feet the clinkering of the cement takes place. At the lower end it emerges in a little stream of hot clinker in small lumps averaging ½ inch in diameter. These fall directly on a horizontal steel box conveyor of the link-belt type, delivering to the boot of a vertical bucket conveyor. (See Figure 15.) The clinker is raised and discharged into an overhead screw and trough conveyor leading over the clinker pile. There are movable slides in the bottom of this screw conveyor permitting of the discharge of the clinker as may be desired. The daily output per kiln is 120 barrels.

The entire wet side of this plant and its kiln equipment show many features which are novel and original, and which reflect much credit on the mechanical skill of its manager. The writer is much indebted to the courtesy of Mr. Stowe for an opportunity to examine it in detail, and to present it fully to the readers of The Engineering Record.

Finishing Mills and Power Plant.

From the clinker pile the cement is delivered by barrow to a conveyor boot, and is carried up and delivered to four Morris mills, Figure 18. These mills are new in cement practice, having been used chiefly in mining work. A mill consists of 13 8-inch balls revolving between upper and lower bearings, the lower of which is driven. The balls are revolved by traction only, and the arrangement is thus simple. At Bronson these mills are used for first reduction, as the material all passes successively through the Morris mills and tube mills. These latter are steel cylinders 4 feet in diameter and 17 feet long, filled within 2 inches of their axes with Norwegian flint pebbles, about an inch

and a half in diameter. They are like the Danish tube mills, but differ in details. The cement is fed through a hollow shaft at one end and discharged through radial slots cut in annular zones through a vertical diaphragm, forming the opposite end of the cylinder. There are three sets of these slots, one exactly in the center, one at the extreme circumference and a third be-

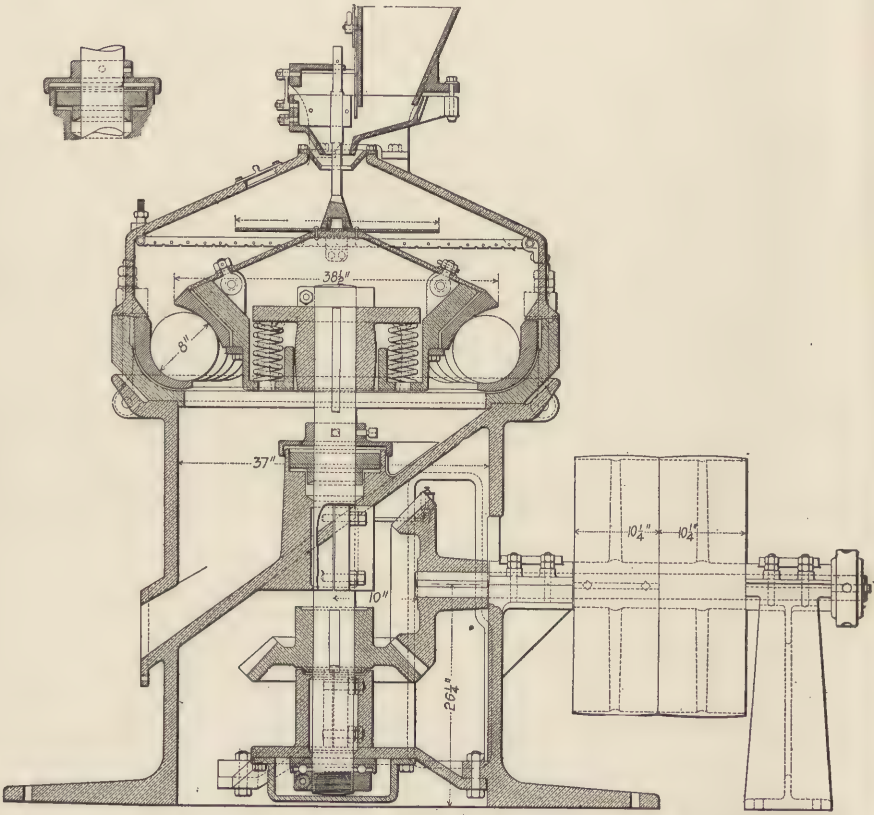

Figure 18.—The Morris Mill.

tween them, and the fineness of the product is determined by discharging them through either set of holes. The coarsest material goes to the outside, and the finest to the center. Each set of the radial slotted openings is opened or closed by the revolution of correspondingly perforated diaphragm plates that

are made through a register in the end of the cylinder. There is a slight air blast maintained in the tube mills.

The tube machines discharge into a conveyor boot that delivers into 20 wooden storage bins of about 800 barrels capacity each, from which the cement is chuted into the packing machine.

A total force of about 100 is required to operate the works at present for an output of 500 barrels a day, for which the plant is adapted, but by the addition of more rotary furnaces and dry grinding machines and 50 more men, it is believed the output can be doubled.

The engine driving the finishing mills is a 250-horse-power Salem Buckeye engine. Besides the two engines mentioned, the special cement machinery for the equipment of the plant comprises a pump on the dredge, a pump on the granulator car, and four more pumps for handling the slurry. The pumps are shown by Figure 14. Each has two plungers actuated by eccentrics on a shaft which is driven through the medium of friction cones, as shown. The contact between the cones is maintained by a ring, and when its position is changed the speed varies. The valves of the pump are of the ball type, as shown. This is a special pump for pumping soft material, made by The Bonnot Company, of Canton, O.

There are four boilers, one 100-light Westinghouse dynamo, one low-pressure duplex Worthington, and two high-pressure Marsh boiler feed pumps, cross connected, two Marsh air compressors, and a 3x8-foot receiver, all built at Battle Creek, Mich. Also two Marsh pumps for handling the oil, and one 400-horse-power Stilwell-Bierce feed-water heater. The machine shop is equipped with a 36-inch lathe, a 3-inch bolt cutter, a small shaping machine, drill press and the usual complement of machinists', smiths', and general bench tools. A full line of oils, electrical supplies, pipe fittings, rotary gears, pulleys, belts, incidentals, etc., is kept in stock.

The laboratory comprises a work room, testing room, and chemist's office, and is located on the first floor of the office and dwelling building. Its equipment is substantially as follows: In the work room are benches, cupboards, and drawers for supplies, and shelves for reagent bottles. A large hood is provided for carrying off noxious vapors, and under it is a large steam bath with a dozen graduated openings. Also a copper steam heating

plate, under which, and also connected with the hood, is a large steam drying oven. There is a sink with hot and cold water and high-pressure water supply passage. A special steam distilling apparatus was designed by Mr. Wheeler, which in continuous use, without attendance, has a capacity of 25 gallons in 10 hours.

The testing room has a work bench with slate mixing slab, a balance for weighing, small hand grinders for pulverizing samples of clinker, etc., four large tanks, 3 feet by 8 feet and 4 inches deep, for immersing briquettes with fixed overflow and water supply connections. A Fairbanks improved 1,000-pound testing machine, and one of 2,000 pounds capacity, mixing machines, compacting machines and a complete set of all requisite apparatus. The chemist's office and balance room contains a Troemner's high grade balance, reading to one-tenth milligram, special supplies, library, filing case, desk, microscope, etc.

The finished product of the plant has been of excellent quality; indeed, some of the test results obtained have been unusual. This is especially true in tests of the finely ground cement in 1 to 3 sand briquettes. Made from raw materials in an extremely fine state of division, the product seems to have a remarkable sand-carrying capacity.

CHAPTER IV.—THE EMPIRE PORTLAND CEMENT PLANT, WARNERS, N. Y.

By Frederick H. Lewis, M. Am. Soc. C. E.

Stretching across Central New York from the Niagara River eastward to the Hudson, and thence turning due south along the west side of the latter river, is found the great Helderberg series of rocks of the New York geology, constituting the most valuable mineral deposits in the State. In this series are found the water-lime and Onondaga groups of rocks, with an immense development of argillaceous shales, marls and shaly limestones, with beds and veins of common salt and of gypsum. Large man-

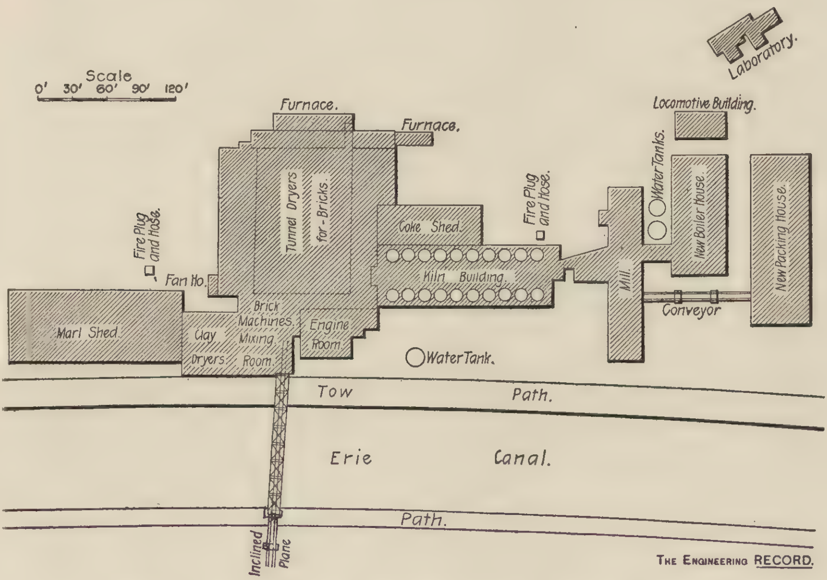

Figure 19.—Plan of the Empire Portland Cement Works.

ufacturers of hydraulic cements, of plaster of paris, of salt and of sulphuric acid, find their raw materials in the rocks of these groups.

The works of the Empire Portland Cement Company are located on one of the extensive marl deposits in this geological

series at Warners, Onondaga County, N. Y. The country in this vicinity is generally flat and inclined to be swampy, and it is in low, wet areas adjacent to the Erie Canal that the marl is obtained. The deposit is immediately below the surface of the ground, in a bed varying from 8 to 15 feet in thickness. Directly underneath the marl, clay is found in abundant supply.

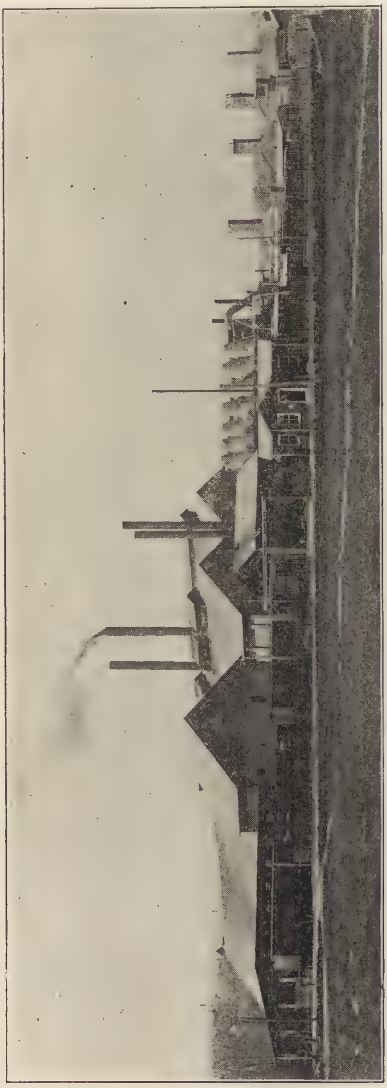

Figure 20.—Works of the Empire Portland Cement Company.

The Empire plant dates from 1886, was the first of the Portland plants in New York, and belongs to the earlier groups of such plants in the United States. In origin, equipment and methods the works are representative of a group of some six or eight manufactories in Central New York making Portland cement from marl and clay by the semi-humid process.

The raw materials analyze as follows:

	Marl, per cent.	Clay, per cent.
SiO_2	0.26	40.48
Al_2O_3 and Fe_2O_3.	0.10	20.95
$CaOCO_2$	94.39	25.80
$MgOCO_2$	0.38	0.99
Loss by ignition	4.64	8.50

The clay is itself a marl in the sense that it is a mixture of clay and carbonate of lime, and the formula for the mixture of

the two ingredients is unusual in that it requires as much clay as marl to give normal proportions for calcination.

The company's property is situated on both sides of the Erie Canal—the buildings on the north side and the raw materials on the south. An iron overhead bridge spans the canal carrying a track into the second story of the raw-material mill. Half a mile distant from the other end of the bridge is the marl pit. In it the raw materials are excavated by clamshell dredges operated by a steam engine, and deposited in service cars running on narrow-gauge tracks alongside. These cars are hauled to the foot of the bridge approach by locomotive and thence are carried up the incline, over the bridge and into the mill by cable. A general plan of the works, Figure 19, illustrates this. Figure 20 is a view of the works looking south and Figure 21 shows the marl bed.

Delivered in this way, the raw materials, especially the marl, contain a large per cent. of water, much more than is required to make bricks for use in shaft kilns. Some of this water can be eliminated by allowing the marl to drain in piles, but the regular practice is to use the marl as received, and to dry the clay in revolving dryers and grind it before mixing.

The detailed arrangement of the raw-material mill is shown in Figure 22. Cars of clay entering by the bridge at the second floor are turned at right angles on a table and the clay dumped on a platform in front of two Cummer revolving dryers, shown at the left of the drawing. The wet clay is regularly charged into the dryers, and as it is discharged in dried lumps below, it is carried by elevator and conveyor to a group of buhrstone mills, and ground nearby. Thence it is elevated to weighing hoppers, to be drawn as required. The wet marl by volume is dumped directly in car-load lots into edge-runner mills set in the half story below the track level. A weighed portion of dried clay is then added and under the molars the mixture of marl and clay is perfected. At times, when the raw materials are wetter than usual, it is necessary to dry a part of this slurry coming from the edge-runner mills, and add it to stiffen up subsequent charges. A third dryer is provided for this purpose.

Charge by charge the slurry is released from the edge runners, carried up and dropped into two vertical pug mills of simple type. The slurry then contains from 30 to 40 per cent. of water

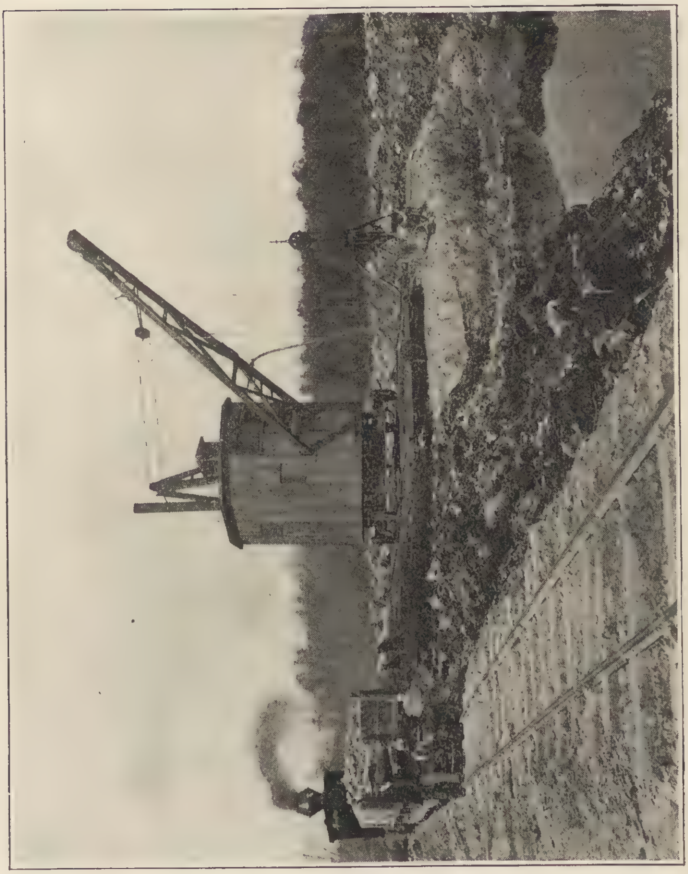

Figure 21.—Method of Excavating Marl.

and is quite plastic, rather too much so for regular brickmaking. A simple and equally effective method of preparing slurry for drying is therefore employed. A workman with a bundle of wooden slats is stationed at each pug mill. He opens the discharge port at the bottom of the mill, draws a slat rapidly past the orifice, and again closes the port. The slats rapidly succeed each other and each carries off a slab of slurry about 3x5 inches in section throughout its length. The slats with their burden of slurry are stacked by other workmen tier upon tier on the shelves of light metal cars made from gaspipe, and these cars as loaded are passed along to a transfer table and either charged at once into one of the drying tunnels or stored on tracks opposite

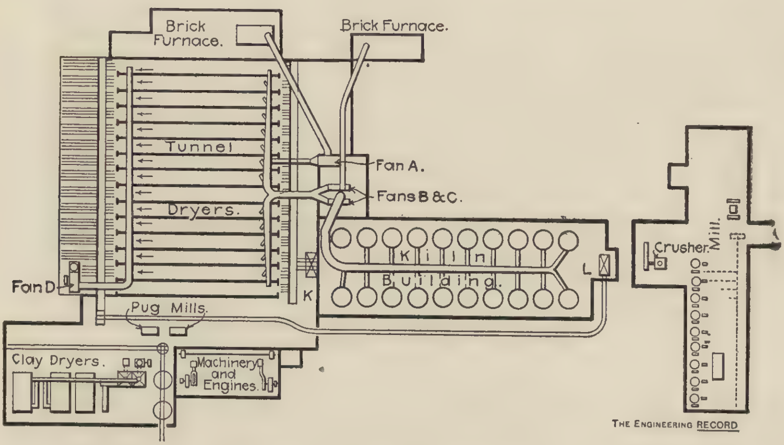

Figure 22.—Plan of Machinery.

the tunnels. In drying the slurry shrinks and cracks into lumps which are generally of suitable size for charging into the kilns.

From Figure 22 the circulation of these service cars will be readily seen. From the pug mills they pass to the transfer table at the left; they traverse the tunnels from left to right; then take another transfer table to the elevator K, by which they are raised to the charging floors of the kilns. The dried slurry is thrown in the kiln doors, dropping off readily from the slats. These are replaced on the cars, which descend by elevator L and return to the pug mills for another charge.

The tunnel dryers shown on Figure 22 are the style made by the Cummer Company, of Cleveland, O. In principle they

consist of (1) a combustion furnace, (2) a fan drawing off the products of combustion from the furnace and lowering their temperature to 300 to 400 degrees Fahrenheit by the addition of several volumes of air, and (3) a series of tunnels through which the heated gases are made to circulate from the fan. The volume of heated gases passing over the slurry is large, but the temperature is moderate. Much more moisture is carried off in this way than by direct drying with higher temperature and smaller volume. The tunnels are of brick, with iron doors at the ends. There are two combustion furnaces with fans, A, B and C, and a third fan, D, aiding circulation by drawing the gases from the opposite end. These combustion furnaces are supplemented by waste heat drawn from the kilns. The kilns are intermittent, and when a charge is burnt out the heat in the clinker is regenerated by closing a damper in the chimney and drawing air through the kiln by the fan C, whence it passes into the tunnels. The economy realized from this arrangement is appreciable in the course of a year, though much the greater part of the heat required for drying comes from the combustion furnaces. It takes about twenty-four hours to dry slurry.

There are eighteen kilns of the regular intermittent dome type, 13 feet in diameter by 45 feet high. They are peculiar only in being contained in a sheet-iron casing, instead of in massive masonry as in European practice. As in all kilns of this type, the kilns are charged up with alternate layers of dried slurry and coke. The side doors are then closed, the kiln ignited from below and allowed to burn itself out. When sufficiently cool the clinker is discharged and the kiln recharged as before.

The clinker discharged from the bottom of the kilns is carefully sorted, the underburnt being calcined a second time. All good clinker is loaded on barrows, which are carried by elevator L to the second floor of the mill, and discharged into a hopper over crushing machinery. By gradual reduction through Blake and roll crushers the clinker is brought to a suitable size for the mills. The mills, ten in number, are rock emery millstones, made by the Sturtevant Mill Company, of Boston, which is also now furnishing a large crusher. The mills have 4-foot and 42-inch stones, some under-runner and some upper-runner mills. There is, besides, one Abbey tube mill installed. In connection with the mills two of the Raymond vacuum separators are

employed, insuring a finished product which is unusually finely ground.

The power plant contains about 625 horse-power in boilers, four being of the horizontal tubular type and two Babcock & Wilcox boilers more recently put in. A 350-horse-power tandem-compound condensing engine drives the raw-material mill. A 150-horse-power Hamilton-Corliss engine is also installed there, and may be used to supplement the power of the larger engine. The large engine is fitted with a Stilwell-Bierce & Smith-Vaile condenser. The water for this is drawn from the canal.

The finished material mill is driven by a 500-horse-power Hamilton-Corliss engine. A belt from the engine leads directly to the pulley upon the main shaft in the basement of the mill building, and running lengthwise of it. Pulleys are mounted on this shaft and from them quarter-turn belts drive pulleys upon vertical shafts, driving each mill.

There is an excellent cooperage, with modern barrel-packing machinery, and an excellent chemical and physical laboratory, the former being unusually well equipped.

The company makes two brands of cement, the Empire and the Flint. A chemical analysis of the finished product is as follows:

	Per cent.		Per cent.
SiO_2	22.04	CaO	60.92
Al_2O_3	6.45	MgO	3.53
Fe_2O_3	3.41	SO_3	2.247

Mr. Charles A. Lockard is the general manager, and Mr. E. Bravender the superintendent and chemist of the company.

CHAPTER V.—THE BUCKEYE PORTLAND CEMENT PLANT, NEAR BELLEFONTAINE, O.

By Frederick H. Lewis, M. Am. Soc. C. E.

The Buckeye plant, at Bellefontaine, O., dates from 1889, when Mr. G. W. Bartholomew and his associates built a double Dietzsch kiln there to develop certain marl deposits which occur at this point for the manufacture of Portland cement. Mr. Bartholomew had previously been connected with the San Antonio Portland cement plant in Texas, and, being familiar with foreign practice, built the new works in Ohio under the plans and advice of the German experts, Meyer and Heintzel and others, as engineers and chemists respectively. Mr. Meyer is the managing

General View of Buckeye Plant.

director of the Dietzsch firm in Germany, which brought out the now well-known Dietzsch kiln; Dr. Heintzel is the distinguished cement technologist of Lueneburg.

The advantage of Bellefontaine as a site for Portland cement manufacture is an abundant supply of raw material, consisting of a large deposit of soft white marl, which occurs here in close proximity to a plastic blue clay. These raw materials are found at a point about six miles north of Bellefontaine, in Logan County, O. The main bed of marl is some 40 feet deep over an area a mile and a half long by three-quarters of a mile wide.

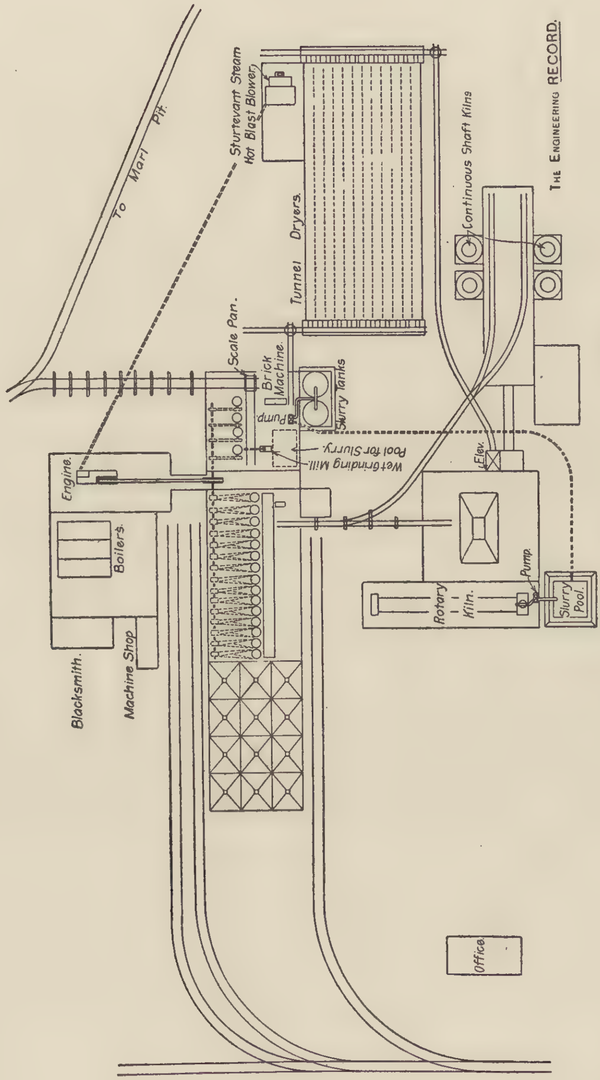

Figure 23.—General Plan of the Works.

The clay lies to the north of the marl, passing under it. In this clay there are also numerous pockets and shallow beds of marl, and it is from these pockets chiefly that the raw material has so far been taken. The main bed of marl therefore is almost intact and constitutes an immense reserve of raw material.

The clay is a smooth, unctuous, glacial clay, and the marl is also supposed to date from the glacial period, being deposited through a long lapse of time in a swamp or lake of glacial origin. The average analysis of these raw materials is as follows:

	Per cent. Marl.	Per cent. Clay.
Carbonate of magnesia	93.00	20.00
Carbonate of lime	1.00	.....
Silica	.....	52.00
Alumina	3.00	17.00
Oxide of iron	.....	5.00
Sulphuric acid	.....	1.00
Loss on ignition	3.00	3.00
Alkalies	.....	2.00

The Buckeye plant is at the present time in an interesting stage of transition. As stated above, there was originally built one double Dietzsch kiln. The raw materials for it were treated by the semi-humid process, making bricks and air-drying them in sheds before calcination. Later four continuous shaft kilns were built upon designs prepared in the company's office. These are in type somewhat similar to the continuous shaft kiln brought out by Mr. Candlot in France. The raw material for these kilns was also introduced in the form of bricks. Within the last year, however, a large rotary kiln of American type has been built, and a part of the plant is now operating on a system of wet grinding, with the calcination of wet raw materials introduced into the rotary kiln by means of a pump. This rotary kiln has been so satisfactory that plans have been made for enlarging the plant by the introduction of others of this type, instead of adding to the shaft kilns with their relatively expensive adjuncts of brick making, brick drying, etc. The general plan of the works, Figure 23, shows the layout as it exists at present. The new rotary kiln is installed just to the left of the Dietzsch kilns and the several pools, tanks and pipe lines for slurry leading to it are also shown.

Because of this state of transition it is necessary to show two sections to illustrate the operation of the raw material or wet mill. The first of these sections, Figure 24, shows the handling

of the raw materials by the semi-humid way for the shaft kilns. The marl enters the mill on service cars by inclined plane. These cars are discharged by hopper into a car running on a track below, which rests at the point where the marl is discharged on a scale beam. In the car on the lower track the marl is thus weighed and clay is added to the charge, by manual labor, from a supply stored in bins adjacent to the scales. As the service cars are loaded with proper proportions by weight of marl and clay they

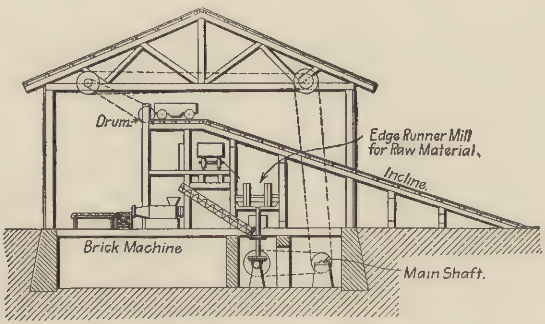

Figure 24.—Old Part of Wet Mill.

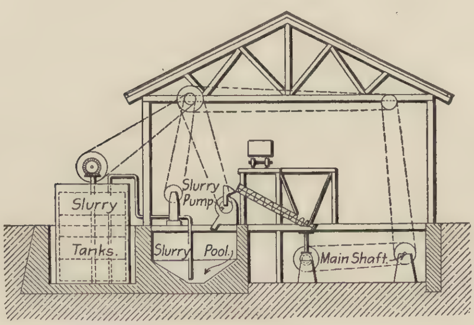

Figure 25.—New Part of Wet Mill.

are run forward and dumped into the pans of edge-runner or molar mills. In these the raw materials are ground during regular time intervals and then dropped through slides in the bottom of the mills to screw conveyors, which carry the slurry forward to a brick machine. There are four of these edge-runner mills. They have pans 9 feet in diameter, each carrying two chasers

5 feet in diameter and 12 inches wide on the running face. The chasers are set on a shaft fixed to the housing of the mill. The pans are driven by bevel gear from countershafts below. This countershaft also runs the screw conveyors. The brick machine is of the screw type.

In the newer scheme, by the wet way, Figure 25, the marl enters as before, and the charge of marl and clay is regulated by weight as before, but the material is dumped from scale cars directly to a screw conveyor which carries it forward to a wet grinding mill. This mill is of the American type for such service, and consists of vertical iron disks revolving rapidly against each other. To the center of these disks the slurry is fed through a hollow shaft and escapes as it is ground from their periphery and falls into a pool below. From this pool the slurry is pumped, as it accumulates, into two steel tanks 10 feet in diameter by 14 feet high, fitted with stirring arbors. The pump handling this slurry can either draw material from the pool below and run it into the tanks, or by changing valves can pump it from the tanks through a pipe leading to a slurry pool at the rear of the rotary kiln. This pool is shown in Figure 23. A second pump located directly alongside of it draws the slurry out and drops it into the rotary kiln.

The output of the double Dietzsch kiln is from 75 to 80 barrels of cement per day, with a fuel consumption averaging about 20 per cent. by weight of cement produced. The continuous shaft kilns produce 50 barrels per day each with a consumption of fuel per day of about 30 per cent. In contrast to these the rotary kiln will produce from 120 to 160 barrels per day with a consumption of solid fuel of about 30 per cent. The output from the rotary furnaces depends somewhat upon the proportions of water in the slurry. The proportion of water varies from 40 to 60 per cent., or even more, but between 50 and 60 per cent. is normal for regular practice.

A considerable series of experiments have been made at the Buckeye plant on the use of powdered coal for the calcination of cement in the rotary kiln. The apparatus used has been of a type developed in Germany for burning such fuel. As a result of these experiments Mr. Bartholomew reports that a very satisfactory system of burning powdered coal for this service has been perfected. An equipment of mills and other apparatus

for operating with such fuel is about to be installed. Meantime the kiln is being run on crude petroleum fuel.

A section of the cement mill is shown in Figure 26. The clinker is ground by a system of gradual reduction, first through a crusher, then through two roller crackers, finishing on millstones and tube mills. One separation is effected, as shown in the section, after the material has passed the first pair of crackers. One crusher and two crackers handle the clinker for 15 run of millstones. These mills are French buhrstones 4 feet in diameter. The clinker is fed to the mills of the size of rice grain or smaller.

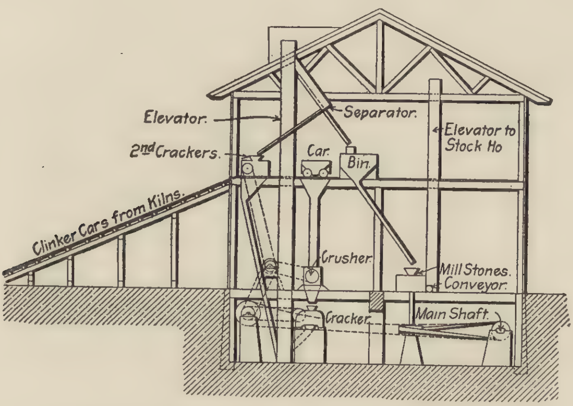

Figure 26.—Section of the Cement Mill.

The power plant of the works consists of three return tubular boilers of 150 horse-power each, two of them being built by Armstrong Brothers of Springfield, O., and the other by Mansfield Machine Works, Mansfield, O. It is necessary to remove the lime from the water, which is quite hard, and for this purpose a Pittsburg chemical filter is used. The mills are driven by a Hamilton-Corliss engine of 250 horse-power nominal capacity.

Supplementing the air drying of bricks for the shaft kilns is a system of tunnel dryers shown in Figure 23, operated by a Sturtevant hot blast system utilizing exhaust steam for heating the air. The greater part of the bricks are now dried in these tunnels.

Laboratory organization follows the German bureau system

Figure 27.—Excavating the Raw Material.

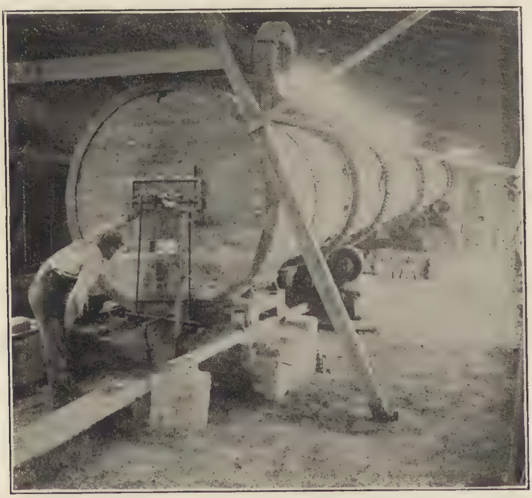

Figure 28.—The Rotary Kiln.

and is more thorough than is usual in American mills. The laboratory is directly alongside the wet mill. It conducts a continuous series of analyses of raw materials regulating mixtures and is in control of this work in the wet mill. The analysis of the Buckeye cement is about as follows:

	Per cent.		Per cent.
SiO_2	21.50	CaO	62.50
Al_2O_3	6.60	MgO	1.20
Fe_2O_3	2.60	SO_3	0.98

CHAPTER VI.—WESTERN PORTLAND CEMENT COMPANY'S PLANT, YANKTON, S. D.

By Frederick H. Lewis, M. Am. Soc. C. E.

On the plains of the West there is an enormous area from Montana to Texas covered by the cretaceous formation and marking the former location of a great inland sea. In this series of rocks are found large deposits of chalk, outcropping at various points from South Dakota to the Gulf of Mexico, which are quite similar in origin and character to those chalks found in Northern Europe, which are so largely employed there for the manufacture of Portland cement.

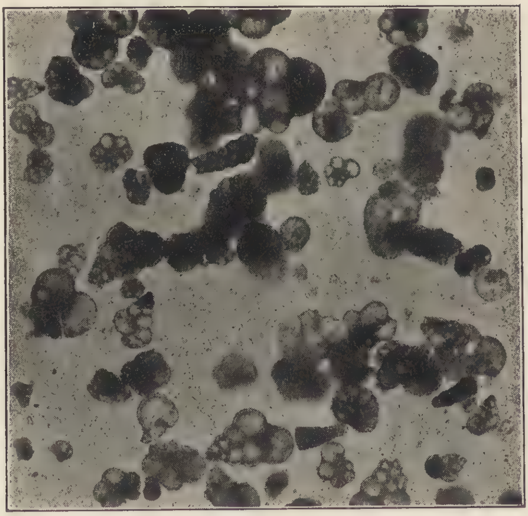

Figure 29.—Microscopic Photograph of Yankton Chalk.

The illustration, Figure 29, prepared by Prof. S. Calvin, State Geologist of Iowa, is a microscopic photograph of the Yankton chalk, and shows it to consist of numberless minute shells, which are said to be identical with those found in European chalks. In South Dakota this chalk formation covers an area of many

hundred square miles northward from the southern boundary of the State. It has at Yankton a thickness of 150 feet, and occurs there directly below the plastic clay subsoil, which is characteristic of large sections of Dakota.

Figure 30 is a photographic view of the excavation in the chalk quarry of the Western Portland Cement Works.* The material lies horizontally in strata which vary from 4 inches to 7 feet in thickness. It is gray in color, quite soft and friable, and after the stripping is done it is readily and cheaply excavated. Between the clay and the chalk is found, however, a bed of bastard chalk, which is apt to be sandy and which must be stripped before the main beds below can be worked.

The analysis of the chalk is as follows:

	Per cent.
Silica	2.0 to 8.5
Alumina and ferric oxide	2.5 to 7.0
Carbonate of lime	94.0 to 84.0

The clay is dark bluish in color, of fine texture and plastic. It analyzes about as follows:

	Per cent.		Per cent.
Silica	58.0	Magnesia	1.8
Alumina	18.0	Sulph. anhydride	1.3
Iron oxide	4.5	Volatile matter	12.1
Lime	1.8	Alkalies, etc.	2.5

In investigating this chalk deposit for cement-making purposes, twelve years ago, the gentlemen interested in the Western Portland Cement Works selected the present site of the works as the most easterly point where the chalk and clay were thus to be found in convenient working position and in close proximity with each other. This site is on the north side of the Missouri River, four miles west of Yankton. The plant was built in 1889-90 from the designs and under the superintendence of Mr. Robert Yates, who had previously visited England and Germany to study methods and plants there. In its general scheme the plan of the work is similar to those found in English Portland cement works on the Thames and Medway. In its details it differs chiefly in the labor-saving devices introduced for handling material and in the scheme adopted for working the slurry and securing homogeneous mixtures. The kilns are

*The writer has prepared this article from data, sketches and photographs furnished him by Professor Nelson O. Whitney of the College of Engineering of the University of Wisconsin, and Mr. Andreas Lundteigen, chemist of the Western Portland Cement Company, and is much indebted to them for the full description which he is able to present of this South Dakota plant.

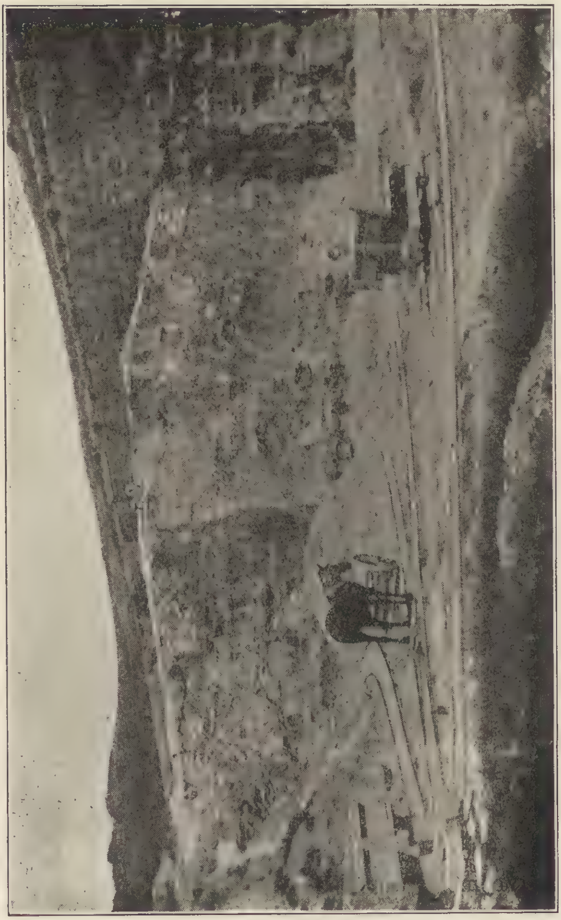

Figure 30.—Chalk Quarry of the Western Portland Cement Works.

of the Johnson type, so generally adopted in England, but the wash mill, which is a feature in English works, is not used.

Figure 31.—The Western Portland Cement Company's Plant.

The general features of the layout as it now exists are the two quarries on the bluffs above, the chalk to the right and the clay to the left; the kiln and mill buildings on the side hill, and the warehouses, drying sheds, etc., in the lateral valley below. A general plan and section of the works is shown in Figure 32. There are six Johnson kilns, with drying chambers and central chimney. Above the kilns is the wet mill, with its machinery and *bassins doseurs*; below them, the cement mill. The power plant is on the hillside, just back of the wet mill, and operates both wet and dry mills, the inclined plane and the cable traction bucket conveyor.

The raw materials enter the wet mill at a high level, the clay running down an inclined plane by cable from the hilltop, while the chalk from a lower level enters the other side of the mill by rail on service cars, drawn by horses. Leading down from the working platform on which the raw materials are weighed, are chutes to two crushers. On these chutes the raw materials are thrown in proper proportions and are crushed to pea size in

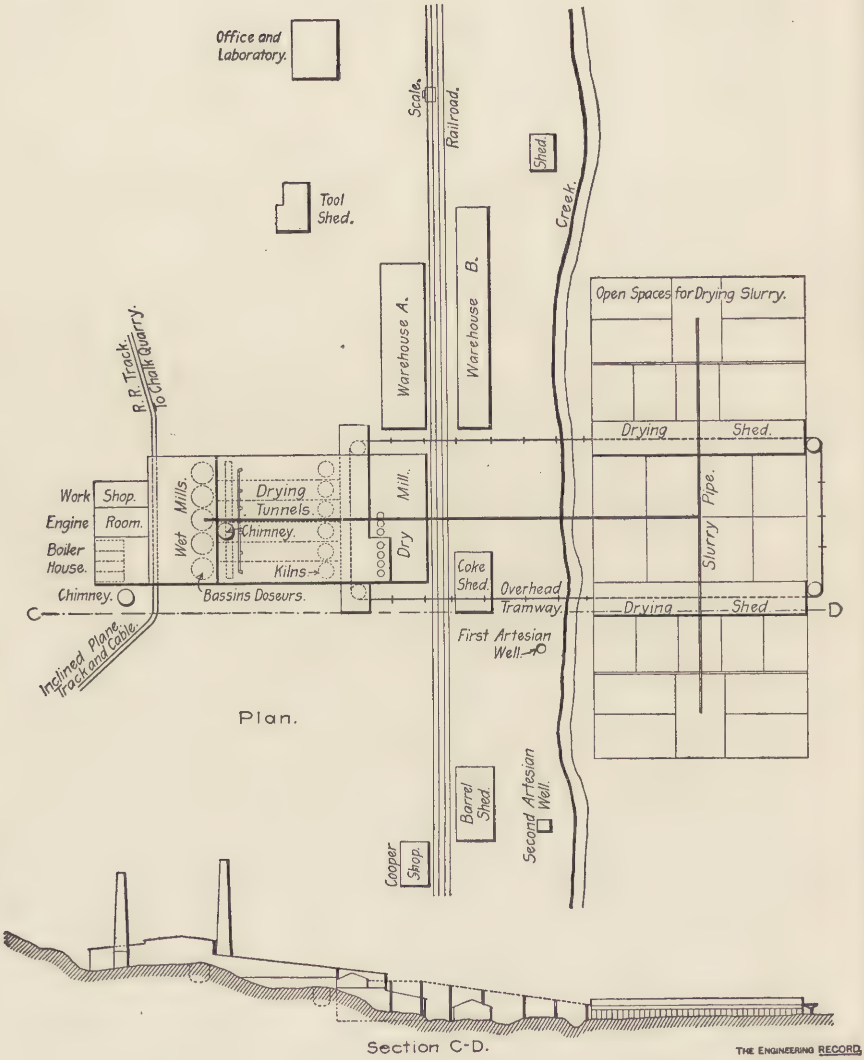

Figure 32.—Plan and Section of the Cement Works.

the machines below. This stuff passes next through machines, one below each crusher, which are peculiar to this plant, designed by its management, and which are known as beaters. These machines are somewhat like horizontal pug mills, except that the shaft revolves more rapidly, and the mixture is wetter and passes out through a wire screen. The operation is continuous. The slurry drops from this pair of beaters into two large tanks or *bassins doseurs,* which have central shafts and stirring arms. A bucket elevator operates in each of these tanks, raising the slurry to the floor above and dropping it into a second pair of beaters. These differ from the first only in the wire screens at the egress end, which are of finer mesh. The slurry passing

Figure 33.—View of the Wet Mill.

through is in a very fine state of division and drops into a second pair of *bassins doseurs* quite similar to the first. From these the slurry is again lifted by bucket conveyors and dropped into a central tank, completing the mixing operation. By conveying all the material in continuous course through two pairs of beaters and through three sets of *bassins doseurs* in series, a very homogeneous mixture can be obtained.

The last tank, the central one of the five *bassins doseurs,* is connected by pipe line with the drying chambers in the flues leading from the kilns and with the open air drying areas in the valley below. The main is 10 inches in diameter and the

branches 8 inches. The slurry is handled by a pump through these pipe lines and discharged at will wherever desired.

The main shaft of the wet mill is run by a rope drive from the flywheel of the engine, and there is a rope drive from the wet mill over the kiln tops to the main shaft of the cement mill below. The different machines in both mills are operated by belts. Figure 33 is a view in the wet mill, showing a pair of beaters in operation.

The Johnson kilns are intermittent in operation; that is, they are charged with alternate layers of dried slurry and coke and then ignited at the base and allowed to burn themselves out. The resulting clinker is then removed and the kiln recharged for another calcination. As operated in England, wet slurry is run into the bottom of the horizontal flues leading from the kilns to the chimney and dried there by the heat of the gases passing

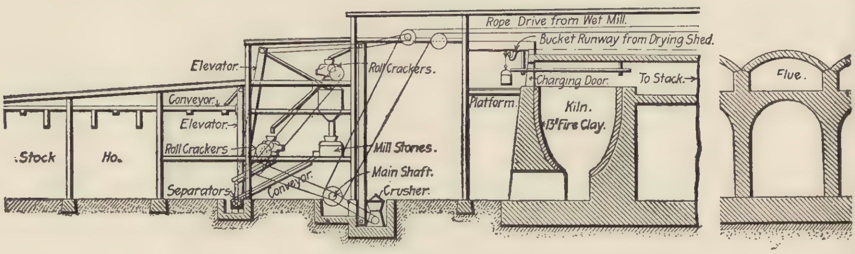

Figure 34.—Section of Kiln and Cement Mill.

over. When a kiln has burnt out it is recharged by taking up the dried slurry in the flue and placing it, with fuel, in the kiln. This process, though utilizing waste gases, nevertheless requires a large charge of fuel in the kilns. At Yankton, therefore, advantage is taken of the wind and sunshine, so abundant there, and a considerable part of the slurry is dried under sheds and in the open. In this way the kilns are operated with a considerably lower percentage of fuel than in English practice, two-thirds or less. This effects an important economy since the fuel, which is at present Milwaukee gas coke, is quite expensive.

The slurry pipe leading from the central *bassin doseur* (Figure 32) thus has a long main running to the yard as well as branches entering the kiln flues. There is also a running rail for buckets, making a circuit in front of the kilns and down through the drying sheds and yard, which is used to bring up the dried slurry

for charging the kilns. The buckets hang from running wheels on the rail and are drawn along by a hemp traction rope, to which they are secured by clips. When charging the kilns a temporary bridge or runway is swung across the kiln and out through the charging door, so that buckets are run directly into the kiln and discharged there with little manual labor. In Figure 34 this running rail and temporary bridge are shown. The kilns are large and low, of the regular Johnson type, with a capacity of 310 barrels of clinker to each charge.

The cement mill is run by a hemp rope drive from the wet mill, passing over the kilns as shown. In milling, the clinker passes first through a crusher, then through two roller crackers and then through millstones. The conveyors, spouts, etc., by which it is carried forward are shown. The product of the second roll crackers and of the millstones passes over Berthelet separators, as indicated in Figure 34. The fine stuff separated from the second cracker goes into the stock house, while the coarse from the millstones is returned for remilling. By means of these separators the stones are always running free on clean material and yield a large output per mill.

The power plant consists of a 500-horse-power Allis-Corliss engine with surface condenser. There are four horizontal return tubular boilers, burning Iowa bituminous coal. Their water supply comes from an artesian well with 6-inch casing pipe. The engine drive, as described above, is by manila ropes to the main shaft, with belts to all countershafts.

The laboratory, under Mr. Lundteigen's care, is very completely equipped for physical and chemical tests, which are conducted with great care and regularity. The plant puts on the market 225 barrels of cement per day of a first quality Portland grade.

The company owns a group of houses for employees, but a majority of these live in Yankton, going and coming daily over a branch railroad owned by the company, from the railroad connections at Yankton to the cement plant.

Mr. William Plankinton, of Milwaukee, is the president of the company; Mr. D. J. Whittemore, Past Pres. Am. Soc. C. E., is its vice-president, and Mr. John Johnston, cashier of the Wisconsin Marine & Fire Insurance Company's Bank, is secretary and treasurer.

Figure 36.—View of Mill from the Northeast.

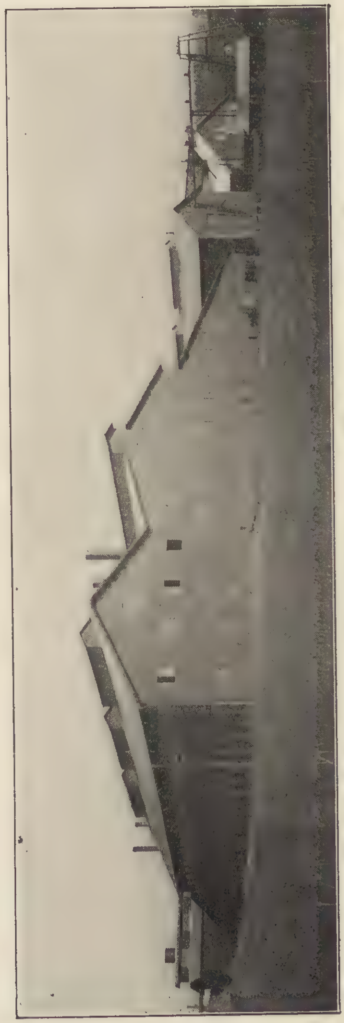

Figure 37.—View of Mill from the Southwest.

CHAPTER VII.—THE NEW WORKS OF THE COPLAY CEMENT COMPANY, COPLAY, PA.

By Henry C. Meyer, Jr.

Since about 1890, the Coplay Cement Company, Coplay, Pa., and the founders of the company before its incorporation, have been manufacturing the Saylor's brand of Portland cement. This industry has grown from a few old-fashioned intermittent bottle kilns, the beginning of plant "A," erected in 1870, to three separate works of a combined capacity of 3,000 barrels per day. The second plant, "B," which was constructed in 1897, was described in The Engineering Record of December 18, 1897. (See Chapter II.) During the past year the third plant, known as "C," which has a maximum capacity of about 1,600 barrels per day, has been constructed, and the purpose of this article is to describe this plant; the necessary plans and data having been furnished by Mr. Charles M. Saeger, the general manager of the company and the designer of this plant and the one constructed in 1898. This journal is also indebted to Mr. George S. Saylor, assistant superintendent of the company, for the photographs of the works. The difference between the two plants is rather striking and shows the advance made recently in the industry. The 1899 plant was provided with continuous kilns of the Danish pattern, which made it necessary to make bricks from the ground raw materials and dry them before burning, while the new plant employs rotary kilns, which, while requiring more fuel for burning, save much more than the difference in the fuel cost in the labor account and in increased capacity on the investment.

The new plant is located about one-eighth of a mile from the others, and a plan of the works, showing the machinery, is given in Figure 35. A photograph showing a view of the buildings from the northeast, with the stock house on the left, and one showing the view from the southwest, are reproduced in Figures 36 and 37. The buildings are entirely of fireproof construction, the walls being either of concrete, brick or corrugated iron.

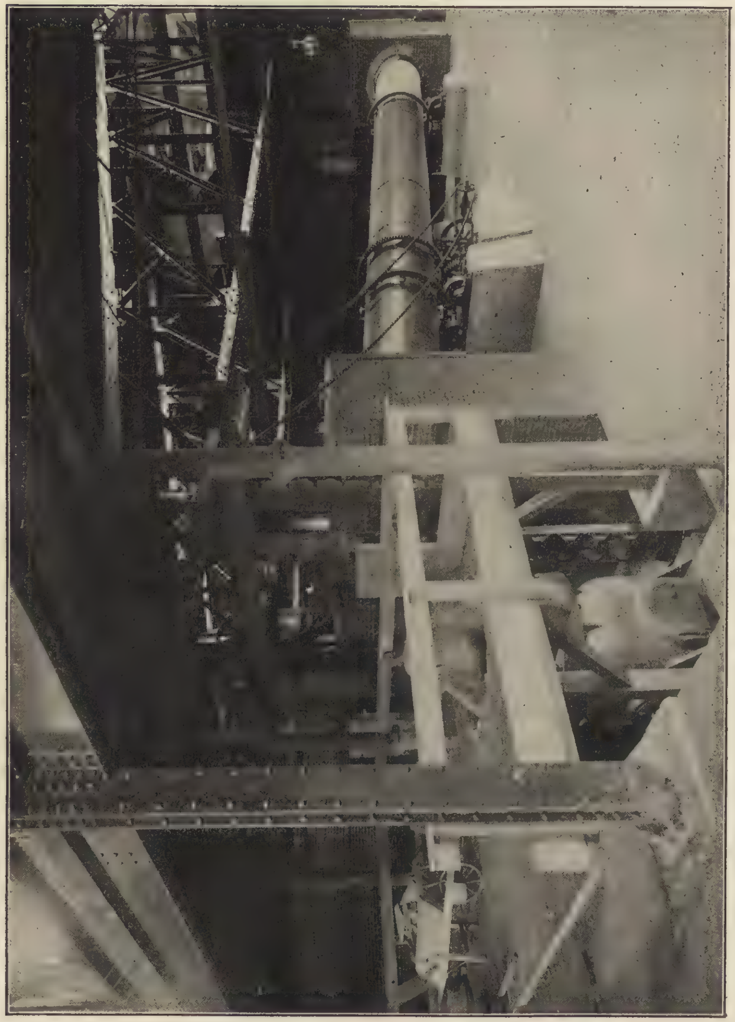

Figure 38.—Arrangement of Crushers and Dryers for Raw Materials.

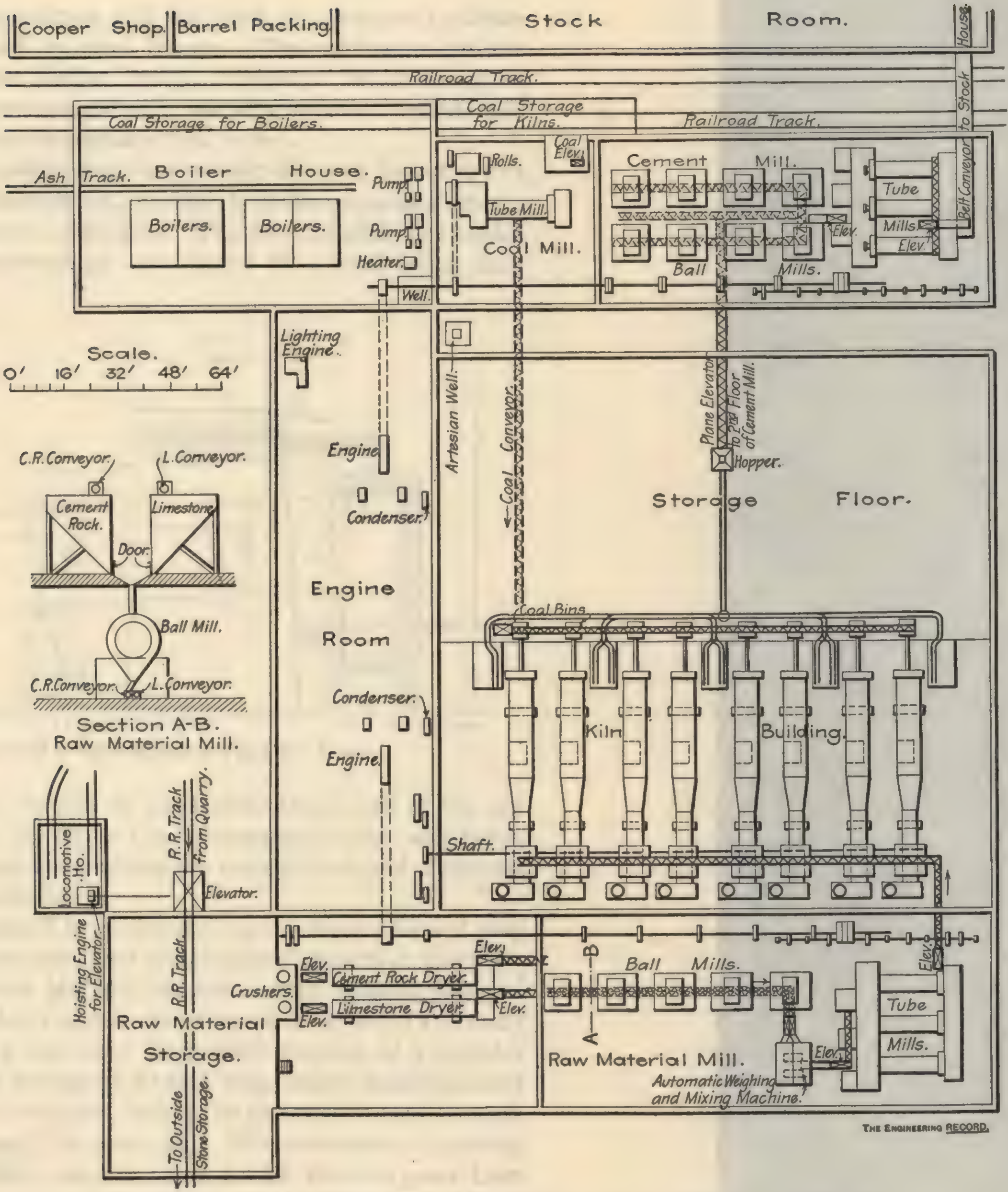

Figure 35.—Plan of Works "C" of the Coplay Cement Company, Coplay, Pa.

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The floors are of concrete and the roofs of corrugated galvanized iron supported by steel trusses. The contractor for the steel work was the Shiffler Bridge Company. When the plant is enlarged the raw material mill, the kiln building, cement mill and stock-house can be extended to the west.

The plant is situated about one-quarter of a mile from the new quarry that has been opened, in which both limestone and cement rock are to be had in abundance. The raw materials are loaded separately on narrow-gauge cars hauled by a small steam loco-

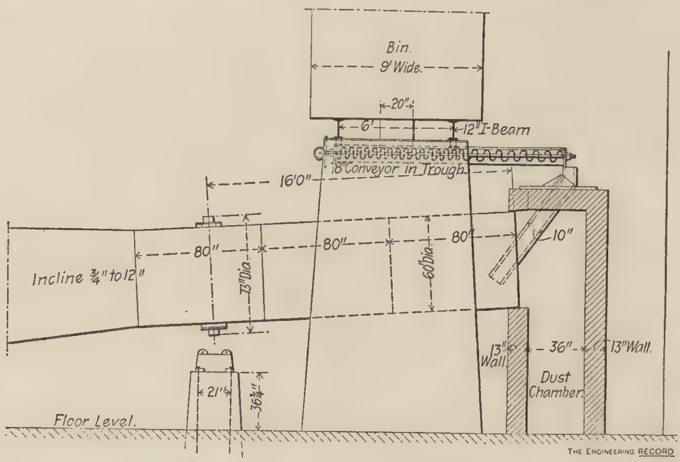

Figure 39.—Raw-Material Feed for Kilns.

motive. The cars are run on an elevator at one end of the raw material building, shown on the accompanying plan, and raised by it to the storage floor, where the cement rock and limestone are piled in separate heaps.

The rock is dumped from the cars on the floor, where it may be stored or may be shovelled directly into hoppers in the floor, communicating with McCully crushers. The crushed material is raised by a bucket elevator into the upper ends of two rotary dryers heated by a coal fire. Each dryer consists of a cylinder 5 feet in diameter and about 40 feet long, which, being inclined slightly from the horizontal, causes the material to pass through the cylinder when it is revolved. The materials in passing through the cylinder come in contact with the hot gases from the coal fire and are dried by them. At the lower end of each dryer an elevator receives the material and lifts it to a conveyor

Figure 40.—Rotary Kilns, Coal-Feeding Apparatus and Clinker Cars.

which finally deposits it in bins, one for cement rock and one for limestone, the crushing, drying and conveying apparatus being in duplicate to keep the limestone and cement rock separate. On the floor below the stock bins mentioned, there are five ball mills into which the raw material passes by gravity. Beneath the ball mills is a double line of screw conveyors, and the delivery spout from each ball mill can be adjusted so as to feed into either conveyor. Each conveyor connects with an elevator, one delivering fine-ground limestone into one bin and the other fine-ground cement rock into another. By this arrangement it is possible to run any ball mill on limestone or cement rock. A cross-sectional view of the machinery in the raw-material mill is given in Figure 39. The conveyors at the top are used to bring the material from the dryers into the stock bins, and, by adjusting the sliding doors in the latter, either cement or limestone may be fed to each ball mill. The object of this arrangement was to avoid mixing the limestone and cement rock until it had been partially ground so that samples, representing correctly the average of each material, could be easily obtained. Samples are taken from the materials in the storage bins and analyzed for the purpose of obtaining the relative quantities that should be mixed. Mixing is done in a machine supplied by the New England Automatic Weighing Machine Company, of Boston, Mass., which weighs and mixes automatically in the proper proportions the ground limestone and cement rock. This machine can be adjusted to supply the materials in any desired proportion.

From this machine the mixed raw materials fall into tube mills, of which there are three, where it is ground very fine, and, of course, thoroughly mixed in the operation. An elevator and two conveyors finally deliver the material to raw-material bins over the upper end of the rotary kilns which are used to burn it to clinker. There are eight kilns, with a separate raw-material bin for each. The material is fed to each kiln by a screw conveyor, which draws the material into a spout feeding it into the upper end of the kiln. The floor on which the kilns are placed is about 6 feet above the floor of the remainder of the kiln building and between each pair of kilns the upper floor is recessed for a distance of 12 feet and a width of 8 feet, so that small cars may be run in on tracks on the lower level and re-

ceive the clinker as it falls from spouts at the lower end of the kilns. One of the photographs, Figure 40, shows this arrangement. The cars are entirely of iron, and around the upper edge of the car body an iron pipe pierced with holes is attached. This pipe may be connected by means of a hose and coupling at each kiln to a water-supply system, and a spray of water used to cool the clinker as it falls into the car. If the clinker is not to be ground immediately, it is stored on the storage floor opposite the kilns, or it may be carried in the cars to a hopper in the floor from which it falls into a special inclined pan conveyor, which carries it to a large storage floor in the second story of the cement mill, where it is finally ground into cement. The pan conveyor connects with a right-and-left screw conveyor which delivers the clinker to any part of this building by means of chutes. The storage floor is of concrete, with heavy steel beams and girders, so that clinker may be deposited for a depth of 8 feet if desired. Openings in the storage floor communicate with ball mills on the floor below, where the materials are partially ground. From these the material is elevated to tube mills where the final grinding is done. The tube and ball mills were all supplied by F. L. Smidth & Company, of New York City. From the tube mills the cement is elevated to a belt conveyor which carries it to the stock house. This is a building 300 feet long and 100 feet wide. About 100 feet of the building is devoted to a cooper shop and barrel-packing department, while the remainder is used to store the cement in bulk. The cement storage is divided by a long longitudinal wall of concrete 3 feet thick at the bottom and 1½ feet at the top and by transverse walls of wood into numerous stock bins. A screw conveyor is located along each outer wall for transporting the cement to the packing room, where it is elevated to barrel packers. A railroad tracks runs along each side of the stock house.

Pulverized coal is used in the rotary kilns to supply the heat. In one end of the cement mill, that adjoining the boiler house, is the machinery for preparing the coal for the kilns. A railway track passes the building and over a pit, partly outside the building and partly beneath it. The coal is dumped into the pit from which it is elevated to the second floor of the cement mill to a dryer similar to that used on raw materials. From the dryer the coal falls by gravity to a pair of Buchanan crushing rolls

made by the George V. Cresson Company, and from the rolls the coal drops into a tube mill located in the pit mentioned. From this it is carried by a screw conveyor and an elevator to coal-storage hoppers, which are placed opposite the lower end of each kiln as shown in Figure 41. A screw conveyor of variable speed forces the coal into a spout in which an air blast carries the coal to the kilns as shown. The air blast is supplied by a small Sturtevant pressure blower. The coal-feeding apparatus is elevated so that the spouts will not interfere with the kiln attendants. The coal-feeding apparatus was supplied by C. H. Gifford & Company, of Philadelphia.

The kiln building adjoins the engine room and either one or two small Atlas engines drives a pulley on the end of a shaft extending into and across the kiln building, for the purpose of

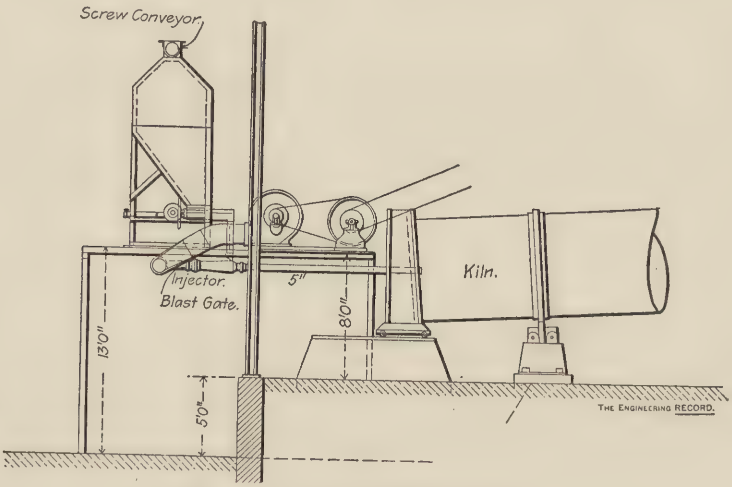

Figure 41.—Coal Feed for Kilns.

driving the kilns. The leather belt driving each kiln is led to a Reeves variable speed countershaft. This device, which was described in detail in The Engineering Record of December 16, 1899 (see Chapter IX.), is made by the Reeves Pulley Company, of Columbus, Ind., and is used to vary the speed of a machine. One of them is also fitted to each of the screw conveyors on the coal-feeding apparatus. From the speed controller on the kilns a leather belt is led to a driving pulley of the kiln and another to the driving pulley of the conveyor for feeding

raw materials to the kilns, so that as the speed of the kilns is varied the amount of materials supplied is proportionally changed. The kilns are 60 feet long, 6½ feet in diameter at the lower end and 5 feet in diameter at the upper end.

Steam at 140 pounds pressure is obtained from four 300-horse-power Stirling water-tube boilers, to which coal is delivered by cars that are run in the boiler house on a trestle, so that coal may be dumped directly on to the boiler-room floor. The engine room contains two 600-horse-power cross-compound condensing engines made by the Buckeye Engine Company, of Salem, O. The location of the engine room made it possible to belt from one engine directly to a large shaft for driving the raw-material department and from the other engine to a shaft driving the finishing mill, stock house and coal machinery. The arrangement is unusually direct and free from complicated power-transmitting machinery. The entire power-transmitting equipment was supplied by the George V. Cresson Company, of Philadelphia, and the conveying and elevating apparatus by the Link-Belt Engineering Company.

The condensers employed are of the Wheeler type with Knowles combined air and circulating pumps. The condensing water is cooled in an artificial pond 300 feet in length and 100 feet wide and divided almost in two by a wall extending from one end nearly to the other. The water from the condensers is discharged through a vertical pipe with a spray nozzle some 12 feet above the surface of the water and falls down in a cascade over steps made of concrete to expose it more fully to the cooling action of the air. This cooling apparatus is shown in the photograph of the works. The water is made to flow entirely around the pond by the wall mentioned, being drawn by the circulating pumps from the side of the pond opposite to the place where it enters. Such of the condensing water as is lost by evaporation and leakage is made up by pumping from the Lehigh River and by rain water from the roofs of the buildings, the leader pipe being led to the pond. A high-duty pump made by the D'Auria Pumping Engine Company, of Philadelphia, driven by steam from one of the old cement plants, raises water into a standpipe for the new works, and this same pump is also used to fill the cooling pond described. The exhaust steam from the engine is condensed and used over again, and to remove as

much of the oil from it as possible an interesting device has been constructed. A Cochrane grease separator is placed in the exhaust pipe; as it is under a partial vacuum, the drip could not be trapped off as is done when the exhaust is under atmospheric or a higher pressure. The drip was led to a perfectly tight tank of considerable volume, and the pipe from the separator was led to this so that the drip flows to the tank by gravity. There is also a separate connection from the exhaust pipe to the tank to equalize the pressure. When the tank is filled with grease and water, a float actuates a whistle and notifies the engineer, so that the tank can be cut off from the exhaust pipe by valves provided for the purpose. It is then placed under atmospheric pressure and its contents drawn off by gravity.

Another rather interesting problem in steam engineering was encountered and solved. The boilers were fed with water from the Lehigh River, which is strongly acid in character, and this caused a very great deal of annoyance and expense—due to corrosion in the boilers—until Mr. Saeger conceived the idea of mixing this supply with sufficient water from the stone quarries, which was found to be alkaline, until they neutralized each other. From the day that was done the trouble ceased.

CHAPTER VIII.—THE PLANT OF THE MICHIGAN PORTLAND CEMENT COMPANY, COLDWATER, MICH.

By Frederick H. Lewis, M. Am. Soc. C. E.

In December, 1898, there was started at Coldwater, Mich., the new Portland cement works of the Michigan Portland Cement Company. This corporation has its general offices in Detroit, and is organized with a capital of $2,500,000, for the purpose of manufacturing Portland cement on a very large scale. The present plant has four kilns, with a capacity of 750 barrels per day, and contracts have been let for adding 10 kilns to this plant, and for the construction of another plant at Quincy, a few miles away. When all the construction work is completed the company expects to operate 28 kilns, with a daily production of about 4,000 barrels of cement.

In these plants the raw materials will be blue clay and a soft amorphous marl, deposits of which occur frequently in the lakes and marshes of Michigan. Hence the raw materials will be handled in the wet way and introduced into the kilns as slurry, containing on an average 50 per cent. of water. The analyses of these raw materials are as follows:

Marl.	Per cent.	Clay.	Per cent.
Carbonate of lime	92.68	Silica	58.24
Carbonate of magnesia	1.72	Iron oxide	7.68
Dissoluble silicates	1.65	Alumina	18.56
Sand	0.32	Calcium oxide	0.61
Organic matter plus moisture	3.43	Magnesia oxide	0.24
Sulphuric acid	0.20	Loss on ignition	10.04

The general method of manufacture at Coldwater is similar to that employed at Bronson, Mich., which was described quite fully in The Engineering Record of April 30, 1898. (See Chapter III.) In detail, however, the method of manufacture differs somewhat, and it is thought these details are of sufficient interest to warrant a description. The works at Coldwater are located on the line of the Lake Shore & Michigan Southern Railway, and consist of a wet mill and kiln building, 75x225 feet in dimensions; a cement mill building, 75x150 feet; a power

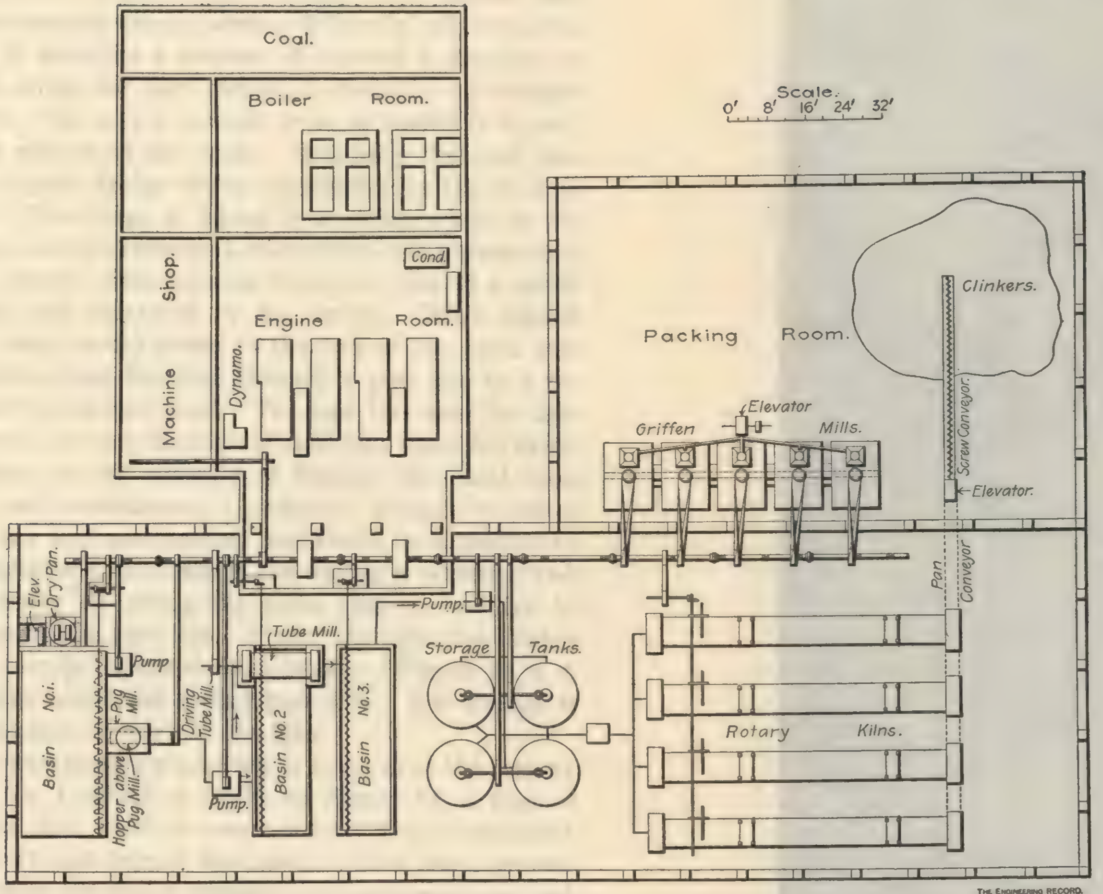

Figure 43.—Plan of Michigan Portland Cement Company's Works.

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house, 75x100 feet, and an office and several outlying buildings. The buildings for manufacturing purposes are built of steel and concrete, and are of substantial construction. The structural work was furnished by the Champion Iron Company, of Kenton, O.

The marl deposit is found along the shores of a shallow lake several hundred acres in extent, about a fifth of a mile from the manufactory. It underlies a stratum of top soil a few feet in depth, beneath which the marl deposit is found to an average depth of 20 feet. The clay is brought from an excellent deposit located about a mile from the works. Originally the marl was excavated by a dipper dredge which deposited it in the hold of a steam barge. This barge is driven by a paddle-wheel in the stern similar to a western river boat, and is thus able to enter and back out of a narrow canal running from the lake to a point near the works, and excavated by the dredge. When loaded with marl the barge would steam to the end of the canal and pump the material from the hold through a pipe line to a receiving basin in the cement plant. The pipe line used for this purpose consists of a 6-inch Root spiral steel pipe some 200 yards long. On account of the difficulty of keeping the canal open in winter-time and maintaining a sufficient amount of water in it, the pipe line has been carried northward on a trestle, so that it now reaches the point where the dredge is working, and avoids the necessity of having the barge pass to and fro to make connection to the pipe line. Under this plan the dredge and the barge may be operated continuously. Figure 42 is a view of the barge connected to the pipe line. The dredge is shown in the distance at work in the lake.

The soft wet marl from the pipe line is received at the cement plant in basin No. 1, which is shown in Figure 43, a plan of the works. The clay, which is comparatively dry, is unloaded in a dry pan shown just beyond this basin. After being ground by the edge runners, the clay is elevated to a platform above, and the mixture of the two raw materials takes place at this point. The marl after being strained from basin No. 1 is dumped into a tank of known volume. This tank discharges into a hopper above a pug mill, and to each charge of marl in the hopper a weighed portion of clay is added. The preliminary mixture of the raw materials then takes place in the pug mill into which

the hopper discharges. The subsequent course of the slurry is readily traced in Figure 43. Discharging from the pug mill, it passes to basin No. 2, from which it is pumped into the tube mill. This mill and the pumps were furnished by the Bonnot Company, of Canton, O., which supplied all the apparatus for handling the raw materials. The mill grinds the wet marl very satisfactorily, discharging it into basin No. 3. From basin No. 3 it is pumped into the four steel storage tanks, which are provided with agitators. These tanks are 14 feet in diameter and 16 feet high, and afford sufficient supply to enable the chemist of the

Figure 42.—View of Pump Barge and Dredge.

works to standardize the mixtures before they pass into the kilns. The delivery of the slurry to the kilns is by means of a pump. The kilns are 6 feet in diameter and 60 feet long, lined with special firebrick. The fuel used is crude petroleum from the Ohio oil fields. The conveying machinery taking the clinker to the mill is shown very clearly on the plans, as is also the arrangement of the Griffin mills for grinding the clinker. This conveying machinery was manufactured by the Jeffrey Manufacturing Company, of Columbus, O. Figure 44 is a view of the

rotary kilns showing the shafting and the gearing for turning them. Figure 45 is a view of the ends of the kilns and shows the main shaft.

The feature of generation and transmission of power has received more than ordinary attention on the part of the owners of the plant, the idea being to generate power as cheaply as possible and to reduce frictional losses to a minimum. The boiler plant consists of four horizontal return tubular boilers, equipped with Murphy stokers, which are intended to burn cheap fuel without smoke and with a fairly good economy. The engines were furnished by the Bates Machine Company, of Joliet, Ill., and the manner of selecting them is interesting in that it was necessary to install a certain amount of power, arranged

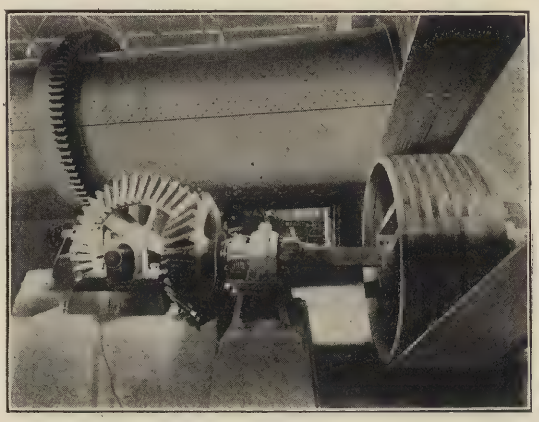

Figure 44.—Driving Gear of Kilns.

so that it could be largely increased when the works were enlarged. Provision was made, therefore, for the ultimate installation of two cross-compound condensing Bates-Corliss engines of about 500 horse-power each. As a total of 400 horse-power in two engines was required at first, the high-pressure side, the shaft and fly wheel of the larger engines were installed, with small temporary high-pressure cylinder, the engines being run as simple condensing engines. As the works are now being enlarged the high-pressure cylinder is to be replaced by a larger one, and a low-pressure side added to each engine, increasing the power from 200 to 500 horse-power for each engine, and making, by compounding, a much more economical machine. The engine

Figure 45.—Interior View of the Kiln Building.

Figure 46.—View of Engine Room, Showing Rope Drive.

may be operated condensing or non-condensing, as desired, a Stilwell-Bierce & Smith-Vaile jet condenser being provided. The condenser draws water from the canal, and discharges it out of doors at a convenient point. A complete pumping plant in duplicate is provided for drawing oil from the storage tanks some distance from the mills and supplying it to the rotary kilns. The engine room contains a Chandler & Taylor automatic engine directly connected to a 120-kilowatt General Electric dynamo supplying some 15 arc and 200 incandescent lights for the buildings.

The general arrangement of the power house and mill is particularly adapted, it will be seen, for the distribution of power with a minimum amount of frictional loss. The American system of rope driving is employed, and transmits power from each engine to the main line shaft, which runs from one end of the mill to the other. A view of the engine room and rope drive is shown in Figure 46. It will be noticed that the wall of the engine room indents the side of the main mill so as to keep the driven pulleys and their friction clutches and several of the large bearings separate from the mill building, where cement dust might be injurious to them. The pug mill, power pumps, rotaries, Griffin mills, etc., are mostly driven by quarter-turn belts from the main shaft, the driving belt in the main shaft being connected by means of friction clutches instead of fast and loose pulleys, as has been the general practice. All of the bearings supporting the main shaft are of the pedestal type, and are mounted upon heavy concrete foundations. The bearings themselves are of special dust-proof type. A ring of felt at either end prevents the dust from entering. These bearings and the entire power transmission equipment were furnished by the Dodge Manufacturing Company, Mishawaka, Ind.

The officers of the company are: William L. Holmes, president; John T. Holmes, secretary and treasurer. The general manager of the works is Mr. L. W. Hoch. Mr. R. D. Hasson is the superintendent, and Mr. Leigh Hunt his assistant. Mr. Oscar Gerlach is the chemist of the company. The writer is indebted to Mr. Hoch for the data and blue prints from which this description was prepared.

CHAPTER IX.—THE WORKS OF THE NAZARETH PORTLAND CEMENT COMPANY, NAZARETH, PA.

By Henry C. Meyer, Jr.

The new works of the Nazareth Portland Cement Company at Nazareth, Pa., have been recently completed and possess a number of features of interest. An attempt was made when the plant was constructed, about a year ago, to utilize the heat in the gases from rotary kilns for generating steam in the boilers of the power plant. The gases from each kiln were led to a vertical boiler which was also fired with coal on an ordinary grate if the demand for steam required it. A chimney carried off the gases from each boiler. When the plant was put in operation, trouble with the draft was encountered so the capacity of the kilns for burning clinker was greatly reduced. This was due to the fact that when the grates were fired with sufficient coal to run the boilers at their rated capacity a back pressure was created in the kiln which naturally retarded its own fire. When Mr. Elvin U. Leh, the present manager of the works, took charge, some months ago, it was decided to give up the attempt to utilize the heat from the kilns, to substitute coal in place of oil as fuel for them and to make other changes of importance. This work has been carried out under Mr. Leh's direction from plans prepared jointly by him and by Mr. Robert F. Wentz of Siegfried, Pa.

The Nazareth works, which now have seven rotary kilns, giving the plant a capacity of about 1,000 barrels a day, are located on the line of the Bangor & Portland Railway Company. The buildings are located on a hillside, as shown in the accompanying illustration, Figure 47. The kiln room, the raw-material and finishing machinery are located in the main building, which has an extension in which the engine room and machine shop is located. The coal mill is located at one end of the kiln room. Coal on cars is run on the trestle shown in the photograph and dumped in a heap by the side of the coal mill. A railroad track

runs on each side of the stock house, which is 250 feet long, thus giving 500 feet of shipping platform.

A plan of the main building with a cross-section through the raw material mill and a cross-section through the kiln room and the finishing mill is given in Figure 48. Cement rock is conveyed from the quarry, about one-half of a mile away, by a Flory cableway and deposited upon the floor of the raw-material storage building. Cement rock and lime rock are weighed out in the proper proportions and dumped in the hopper of either a McCully or a Gates crusher, from which the rock runs by gravity into Mosser crushers on a lower floor, which reduces the material to a finer size. From the last crusher the material is passed through a rotary dryer heated by a coal fire. This was designed by Mr. Leh, and consists essentially of a cylinder made of boiler steel about 4 feet in diameter and 36 feet long. The cylinder is enclosed in a brick chamber and fire is built on a grate at one end, the gases passing to the other end outside of the steel shell. They then enter the shell by means of perforations in it, and return to the grate end of the dryer, inside of the shell, and in direct contact with the material to be dried. The shell, at the grate end, is slightly

Figure 47.—Works of the Nazareth Portland Cement Company.

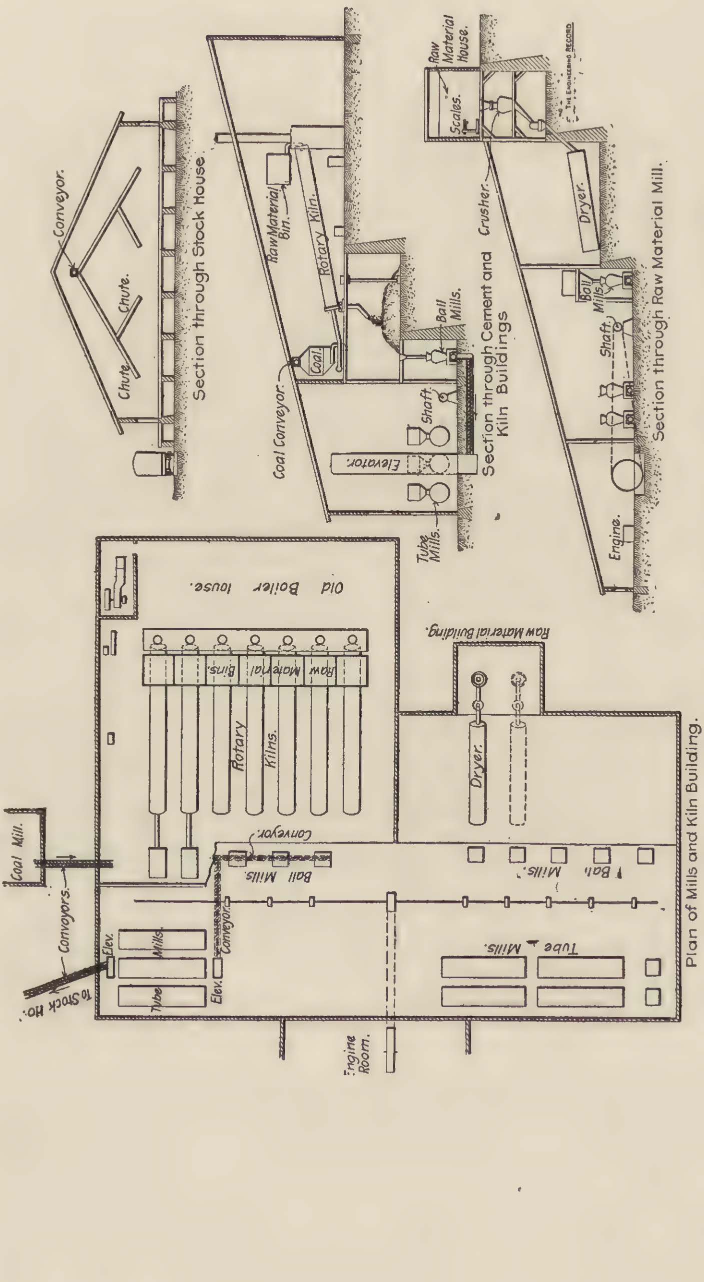

Figure 48.—The Main Building and Section Through Stock House.

higher than the other end, and this causes the material to pass from the high to the lower end when the shell is revolved. The heated current of air coming in contact with the raw material rapidly takes up the moisture that it contains.

From the dryer the raw material is elevated to storage bins in the raw-material mill, from which it is sent in chutes to Smidth ball mills, of which there are three being installed. From these mills the raw material is elevated and conveyed to three Smidth tube mills. The arrangement contemplates an ultimate installation of six ball mills and six tube mills.

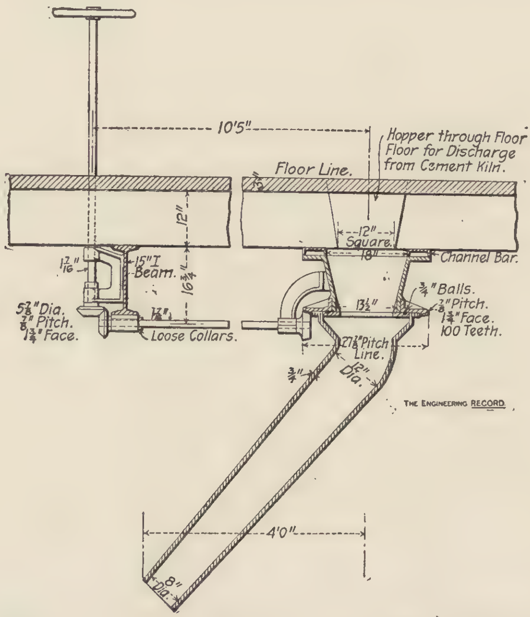

Figure 49.—Rotary Spout for Spreading Clinker.

The ground raw material is elevated and then conveyed to bins over the upper ends of the rotary kilns shown in the illustrations. The bottom of each bin is V-shaped and has an opening in the bottom allowing the material to fall into a small conveyor which forces the material to the delivery spout leading to each kiln. The small conveyors are driven at constant speed and the amount of coal that they deliver is controlled by slides regulating the opening in the bottom of the bin. The clinker drops from the lower end of the kilns through an opening in

the floor into a rotary spout which delivers it to a cooling floor on a lower story, as shown in the sectional view of the kiln building. The rotary spout can be rotated by turning the hand wheel which is connected by the gearing shown in Figure 49. The advantage of this device is that the hot clinker may be distributed in one spot until a heap of it accumulates. The spout can then be moved so that more clinker is deposited in another locality, while the first is being cooled and removed. After the clinker is cooled, it is shoveled in openings in the floor which communicate with Smidth ball mills located on a lower story. There are five of them. From the ball mills the partly ground product is conveyed and elevated to bins over three West pulverizers or tube mills, where the finishing process is accomplished. The finished cement passes from the tube mills into an elevator that delivers it to a belt conveyor running from the upper part of the finishing mill to the stock house.

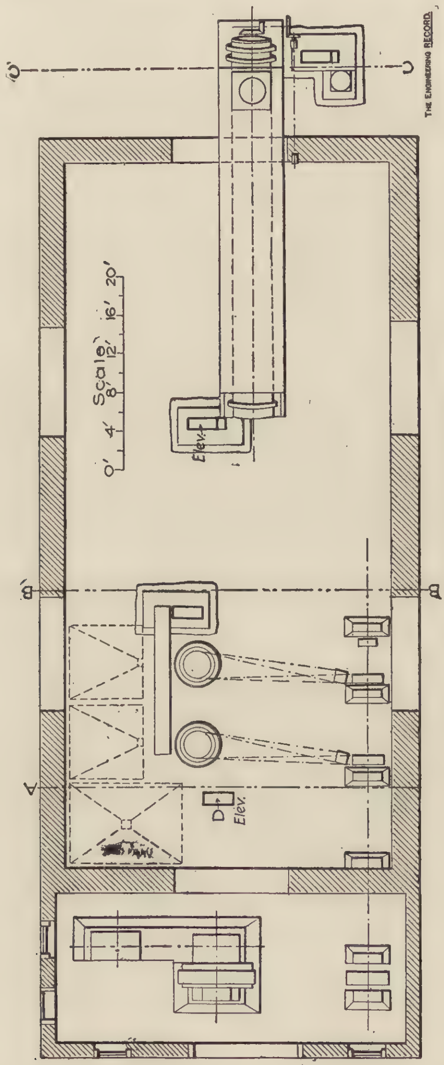

Figure 50.—Plan of the Coal Mill.

The stock house is shown in section, in Figure 48. It is

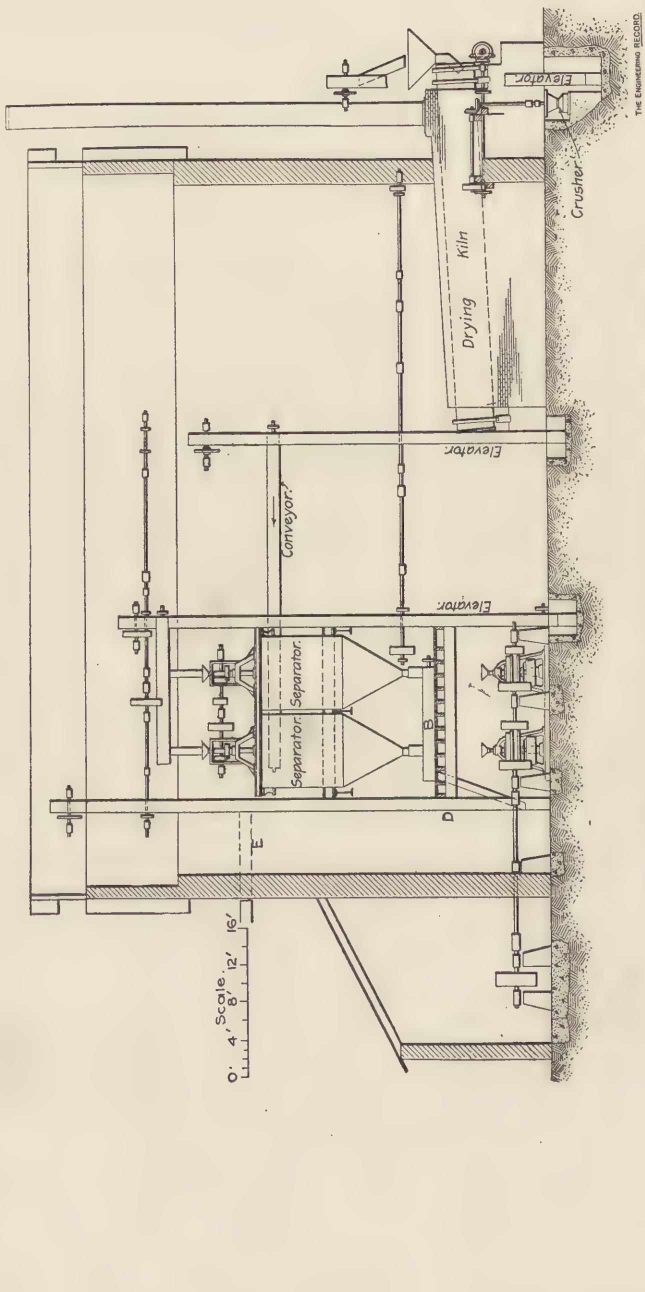

Figure 51.—Longitudinal Section Through Coal Mill.

250 feet long and 105 feet wide. The building is of stone with a wooden roof. The finished product enters the building on a belt conveyor which delivers it to a screw conveyor running lengthwise of the building. At various points, openings in the bottom of the conveyor are provided communicating with chutes leading to storage bins on the floor of the building. After the cement has seasoned for a sufficient length of time it is elevated to barrel packers and there packed for shipment.

The illustrations of the coal mill show a plan, Figure 50, a longitudinal section, Figure 51, and three cross-sections, Figure 52. The coal used is West Virginia semi-bituminous. It is dumped from cars on the trestle in a pile alongside of the coal mill. The preliminary crushing of the coal is done out of doors, the coal being shoveled into the crusher that is set in a concrete pit at the end of the building. It is then elevated into a dryer similar to that used on raw materials, and from this the coal is elevated and conveyed into the hopper, A, as shown in the section, B B, from which it runs into a pulverizer. The coal is then elevated to a separator, where the dust is separated from the coarser particles, the former passing into the conveyor, B, and the latter passing again into the pulverizer by the pipe, C. The dust is carried by the conveyor, B, and the elevator, D, section A A, to the storage bin, which has a capacity of 40 tons, or to the conveyor at E, shown in section A A, leading to the kiln room. By means of the pipe, F, and the elevator, the coal in the storage bin is supplied to the conveyor, E. The coal enters the kiln room and is discharged into a coal feed system supplied by C. H. Gifford & Company, of Philadelphia. It consists of an iron hopper for each kiln, from which the coal dust falls into a small screw conveyor at the bottom of the hopper, the conveyor forcing the coal through a small pipe that drops into a pipe through which there is an air blast, supplied by a Sturtevant pressure blower. The air blast carries the coal into the kiln, where it is burned.

The amount of coal supplied depends upon the speed of the screw conveyor, and this is controlled by a speed controller recently put upon the market by the Reeves Pulley Company, of Columbus, Ind. This device is shown in plan and elevation in Figure 53, and also in a reproduction of a photograph, in Figure 54. It consists of a pair of shafts, a driver and a driven

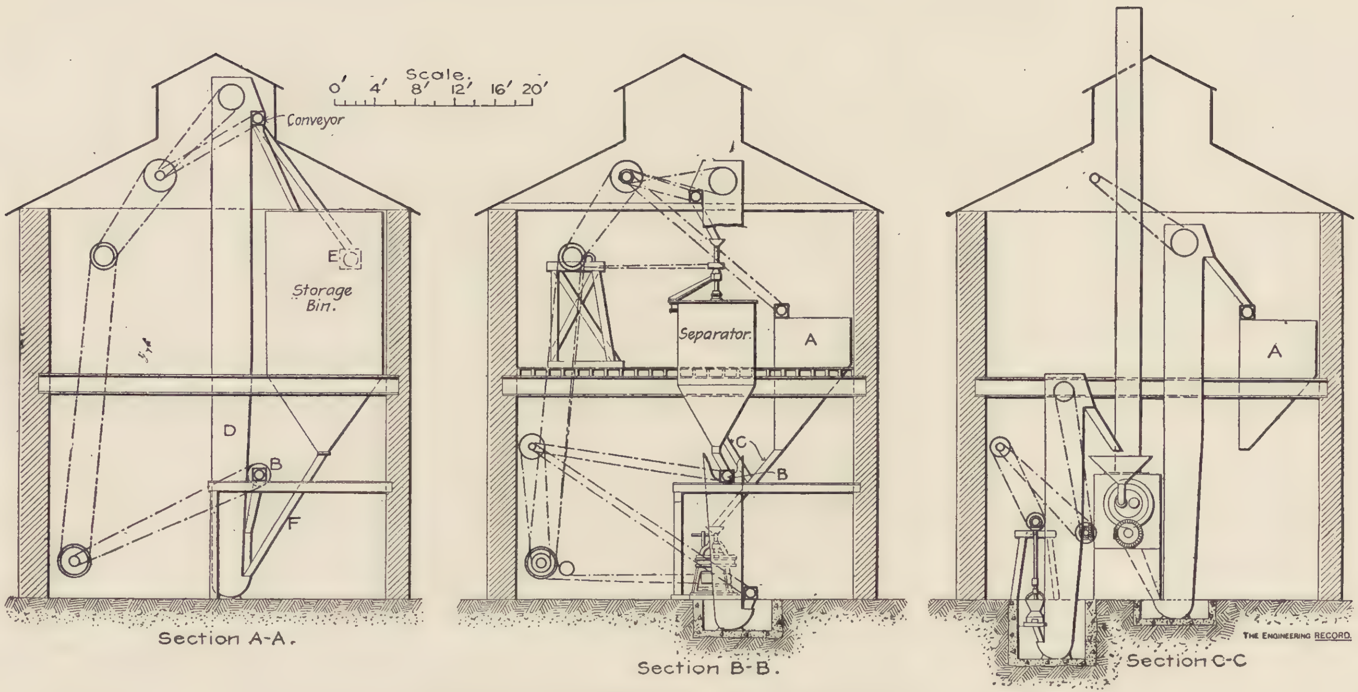

Figure 52.—Sections Through the Coal Mill.

shaft. The former is connected by a friction clutch to the line shaft driving all of the kilns, and the latter is connected by a bevel gear to the screw conveyor. The two shafts of the speed controller are connected by a belt. The pulleys are not of the usual kind. A pair of conical disks are keyed to each shaft. The relative position of these cones is fixed by a lever, controlled by a screw, so applied as to move one cone away from its mate as it moves the other toward its mate. The belt is much thicker than is usual and its sides bear against the faces of the cones. As one pair of cones is separated as the other pair is moved closer

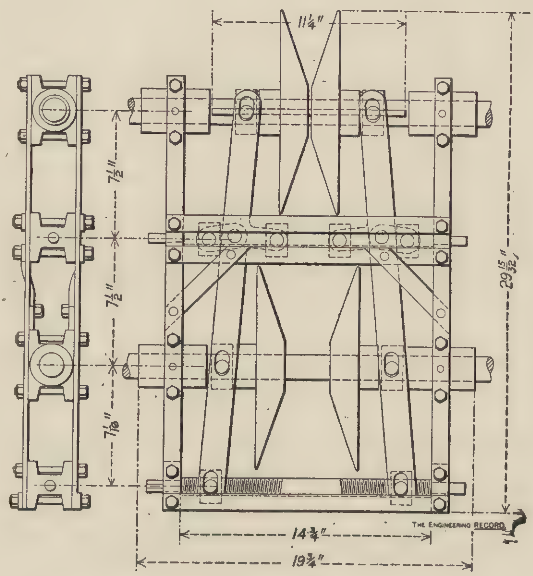

Figure 53.—The Reeves Speed Controller.

together, it will be seen that the diameter of the circle assumed by the belts in passing around each pair of cones varies, hence the relative angular velocities of the shaft change. These speed-controllers are also used to vary the speed of the kilns. A belt from a line shaft leads to a controller from which a link belt leads to the kiln-driving mechanism. Figure 55 shows the method of attaching these controllers to the kilns. The belt marked A in the picture was used while the controllers were being installed and is only temporary.

Steam was formerly generated by Cook boilers located at the upper end of the kilns. These are now being moved into a new boiler house adjacent to the engine room. This will contain the Cook boilers and one 200-horse-power Babcock & Wilcox boiler. The raw-material and finishing mills are driven by an 800-horse-power engine furnished by the Fitchburg Steam Engine Company, of Fitchburg, Mass. It is of the compound non-condensing type and has cylinders 20 and 36 inches in diameter and 48-inch stroke. The exhaust steam is passed through a feed-water heater

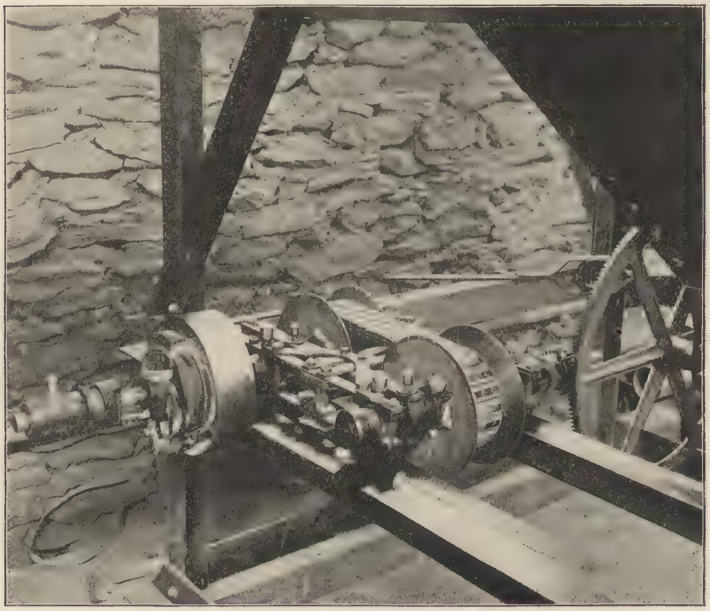

Figure 54.—The Speed Controller of the Screw Conveyor.

on its way to the atmosphere. The water supply is from a driven well and the water is pumped to a stand-pipe located on the hill, so as to give a pressure of 60 pounds on the pump. Numerous fire hydrants are supplied from this stand-pipe. The feed water is drawn from the stand-pipe into a cistern outside of the engine room. The boiler feed pump draws its supply from this and all high-pressure steam traps are discharged into the cistern to utilize the heat they contain.

A belt from the engine leads directly to a pulley on a line shaft running through the raw-material and finishing mills. Belts lead directly from pulleys on this shaft to friction clutches on each machine. The kilns and coal-feeding machinery are driven by a 40-horse-power engine furnished by the Phoenix Iron Works Company and located in the corner of the kiln building. The coal mill is driven by a 100-horse-power Putnam engine, and a stock house is driven by a shaft that extends from the power-transmitting system in the finishing mill.

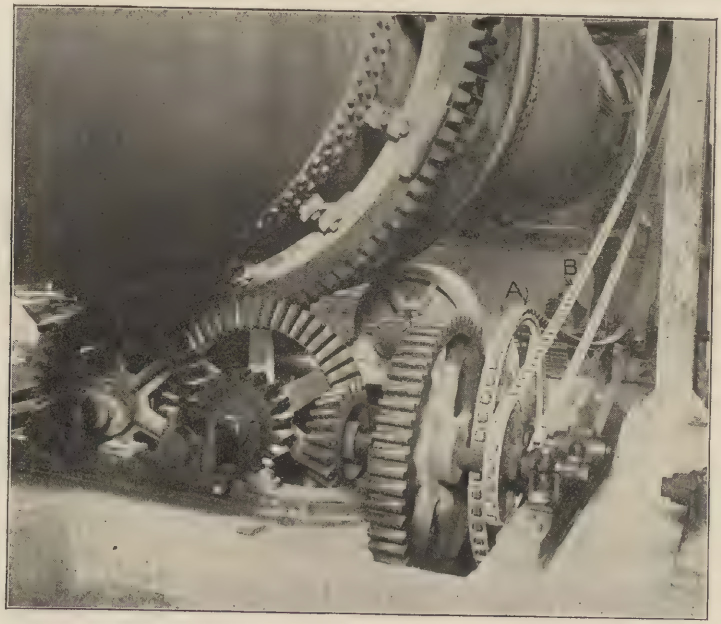

Figure 55.—The Controller Applied to Kiln-Driving Machinery.

The officers of the Nazareth Portland Cement Company are: Dr. James P. Bornes, president; Conrad Miller, vice-president; Dr. A. S. Rabinold, secretary and treasurer, and Hon. Edward Harvey, Truman Dodson, Marcus Kline and Henry Kramer, directors. To these gentlemen, to Mr. J. Maxwell Carrere of New York, and to the manager of the works, Mr. E. U. Leh, The Engineering Record is indebted for courtesies extended in the preparation of this article.

CHAPTER X.—THE VULCANITE PORTLAND CEMENT COMPANY'S WORKS, VULCANITE, N. J.

By Frederick H. Lewis, M. Am. Soc. C. E.

The Vulcanite Portland Cement Company, of Philadelphia, is intimately associated in ownership and in its directorate with a much older corporation, known as the Vulcanite Paving Company, which has been identified for many years with the asphalt

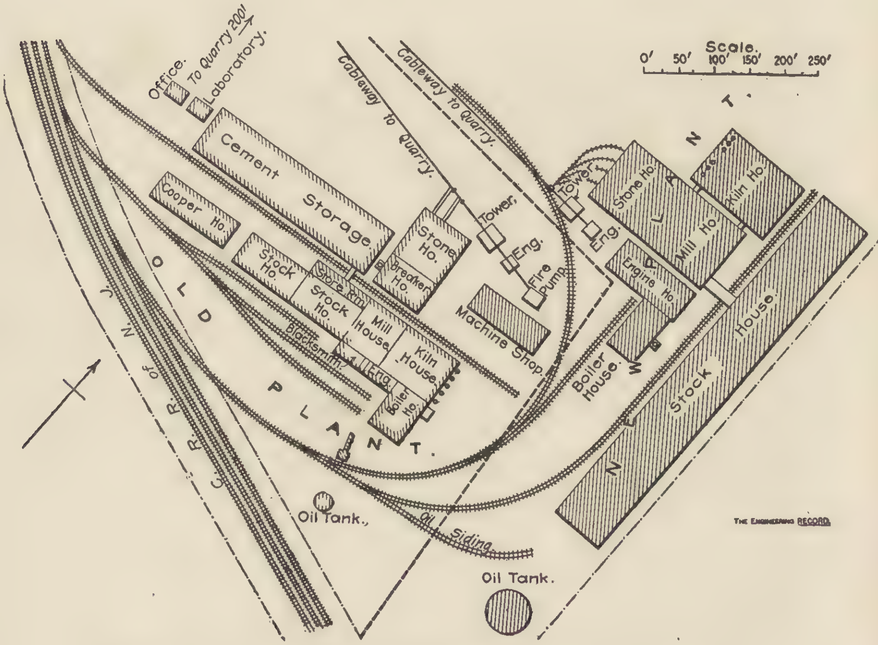

Figure 56.—The Old and New Cement Plants at Vulcanite, N. J.

and cement pavement business in Philadelphia. Indeed the plant at Vulcanite, N. J., originated some five years ago in the desire of the Vulcanite Paving Company to be able to command an assured supply of Portland cement of the quality required for its paving business.

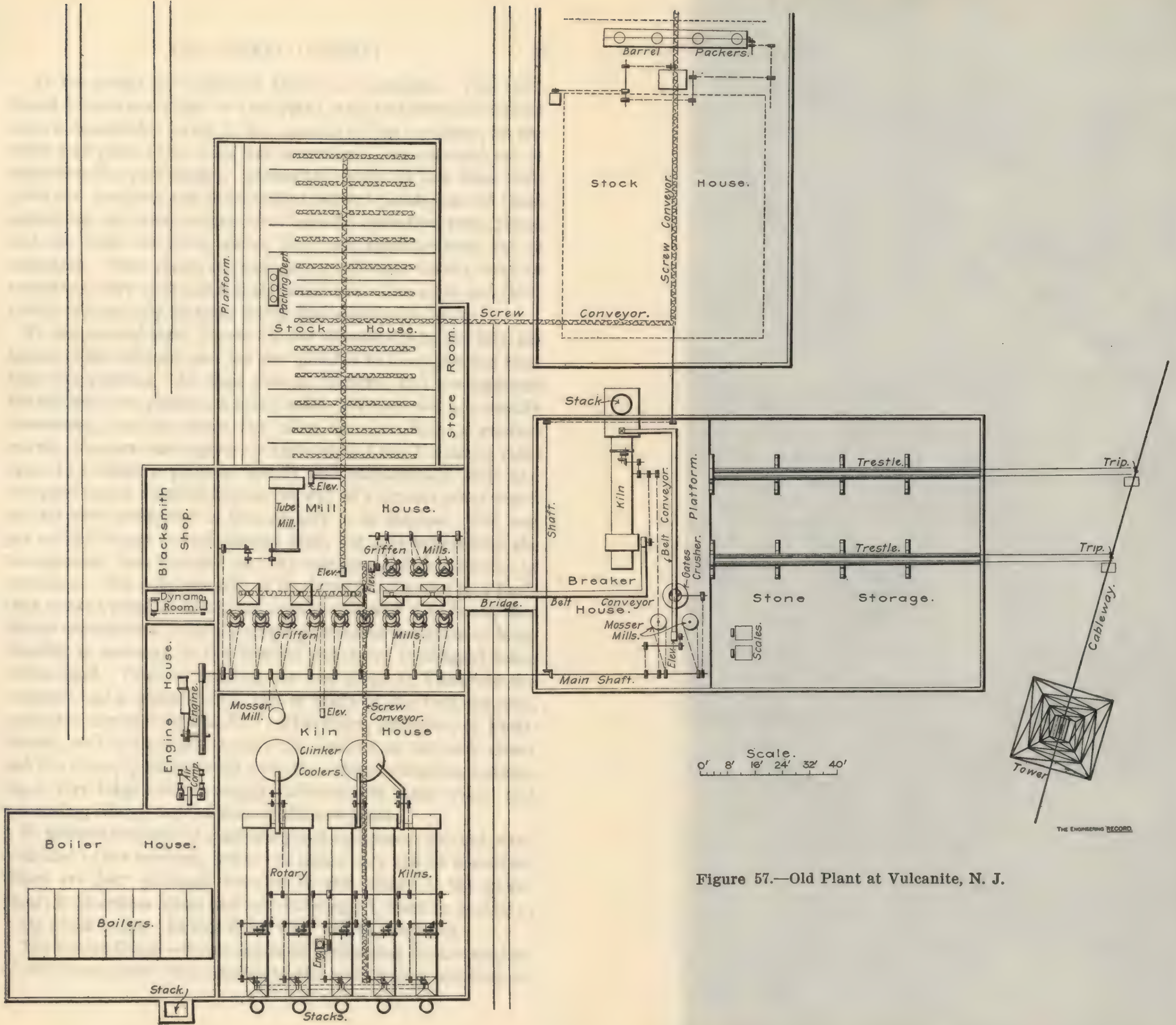

Figure 57.—Old Plant at Vulcanite, N. J.

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At the outset three 40-foot kilns were installed. Two additional kilns were added to this plant, and as further additions were impracticable owing to the location of the buildings, an entirely new plant of six kilns was constructed last year and put in operation the past winter. Hence the works at this time comprise two complete and independent cement plants, one of them containing five kilns, which have been in operation some years, and the other six kilns, which have just recently been put in operation. Both plants are complete in all their details, even to separate quarry outfits and cable tramways. The office and laboratory are the only features which are common to both.

In the general plan, Figure 56, the old plant is to the left, adjacent to the railroad, and the new plant is to the right and back from the railroad. In their general features and arrangement the old and new plants are much alike, but they are not equally interesting, because while the older one has been a gradual growth, the new one represents the views of the Vulcanite managers in a modern plant as solidly and substantially built and equipped as any construction in the way of a cement plant which has yet been attempted in this country or in Europe. The cost per unit of output is undoubtedly high, but it is believed by the management that this will be fully compensated by economy of operation. The duty required of machinery and power in a Portland cement plant is heavy and continuous, and it is found that liberal expenditure to install ample power and machines of large capacity is economy in the broader and more intelligent sense of the word. Prior to building the new plant at Vulcanite the company had a diamond-drill survey made of the rock deposits, under the direction of Mr. E. V. d'Invilliers, geologist, of Philadelphia, and in this way located the position of the rock strata and the quantity of available rock for cement purposes, indicating a very large reserve supply sufficient for many years, and warranting a large expenditure on the new plant.

In general features of machinery and equipment the old plant is similar to the new one, hence the latter only will be described. There are four principal features in this plant; 1, the power plant; 2, the stone house and mill building; 3, the kiln building; 4, the stock house. In this order they will be described.

The Power Plant.—Two compound condensing Corliss engines of 500 horse-power each constitute the main power installation.

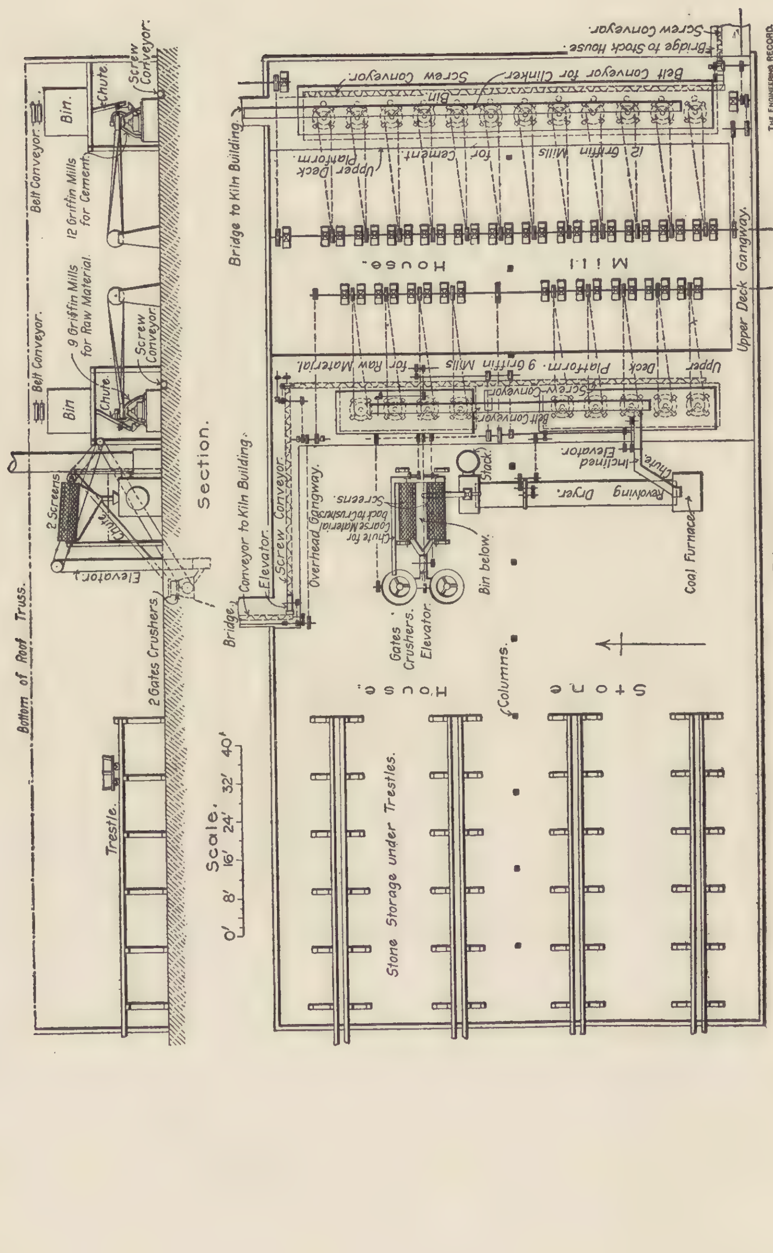

Figure 59.—The Stone House and Mill Building.

They were built by the Pennsylvania Iron Works, of Philadelphia. A view of the interior of the engine room is shown in Figure 63. The two engines drive different shafts spaced about 12 feet centers and leading across the mill building. (See Figure 58.) One drives the stone house and raw-material mills with their accessories, conveyors, elevators, etc. The other drives the cement mill, clinker crackers, stockhouse conveyor, etc. The one thus

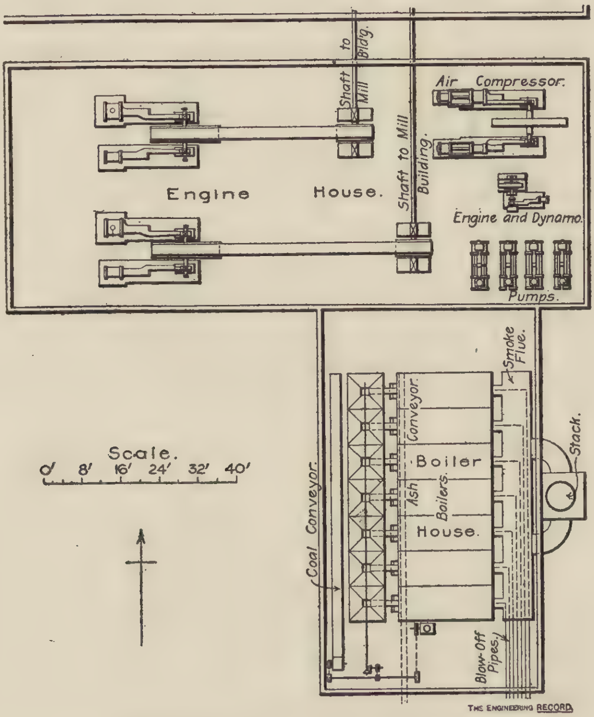

Figure 58.—New Power Plant.

handles all machinery required for raw material from the stonehouse to the bins at the back of the kilns; the other, all machinery required to handle cement from the clinker crackers to the stockhouse bins.

Each side of the mill is thus entirely independent of the other in the matter of power. The kilns and their accessories and the stockhouse and its accessories are run by auxiliary engines set up in the respective buildings. The kilns are thus run regardless

of whether the mills are in operation or not, and the stockhouse machinery is operated or stopped irrespective of work going on elsewhere. This general scheme of distribution of power is undoubtedly correct, and has been admirably carried out at Vul-

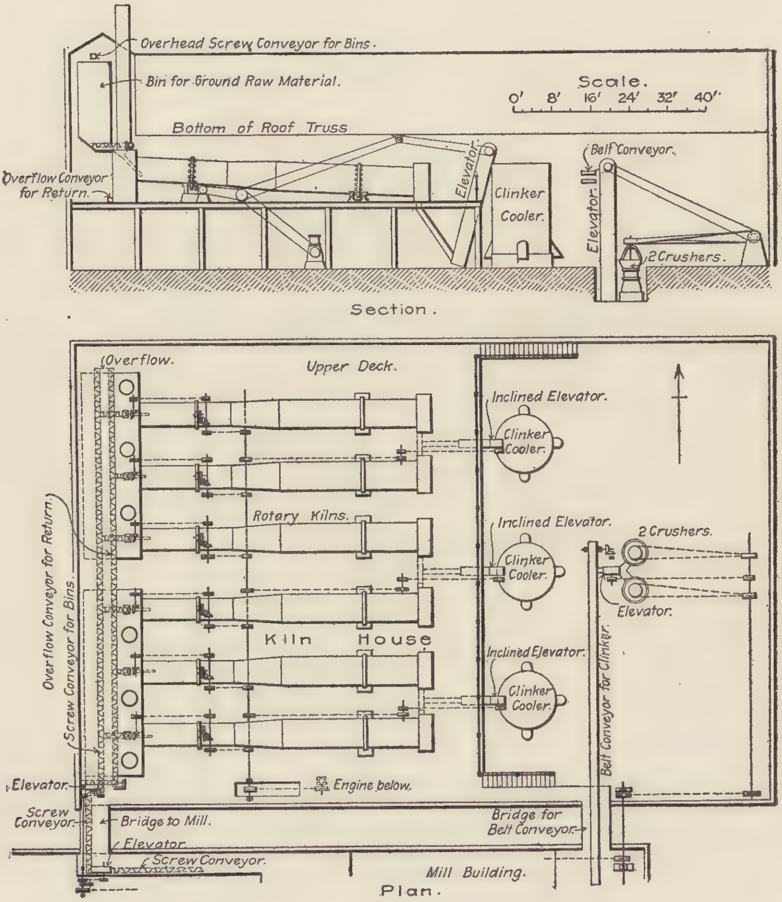

Figure 60.—The Kiln Building.

canite, as will be seen by examination of Figures 58, 59 and 60. A small auxiliary engine will also be seen in the boiler house operating the Wilkinson stoker with its elevator, conveyors and coal pockets.

Besides power engines there is an Ingersoll-Sergeant air com-

pressor, an electric generating set and the pumping engines. The boiler plant consists of seven return tubular boilers of 150 horse-power each, built by Henry Goldner & Son, of Philadelphia. As indicated above, they are equipped with the complete Wilkinson stoker for handling and feeding coal and discharging ashes. Each boiler has independent blow-off pipes set in the passage under the smoke flue. The high standard of excellence in this power installation will be apparent.

The Mill Building.—At Vulcanite the cement rock is brought from the quarry in skips, on a rope tramway, furnished by the S. Flory Manufacturing Company, of Bangor, Pa. It is discharged from the skips at a tipple into service cars. The limestone required for perfecting the cement mixture is received by rail. Both grades of stone are dumped on the floor under the trestles shown in the stone house, Figure 59, and a sufficient stock is maintained at all times on the floor to permit of making the necessary analyses and computations for proportioning mixtures. These mixtures are made by weight, as the stone is charged into a crusher and begins the process of reduction. It is practicable to make the mixture at the outset in this way because the two grades of stones are practically the same in hardness, gravity, etc. There are two Gates crushers set at different gauge, each discharging into the foot of the elevator shown between them. The stone is thrown into the one at the right, and on passing through is elevated to revolving plate screens made by the Gates Company. These screens are carried overhead on a trestle and are perforated with $\frac{3}{4}$-inch holes. All material which passes through the screens falls into a hopper below, and thence passes by a chute into a dryer. Material which is too large for the screens passes out of them at the lower end and thence falls by a chute into a second Gates crusher.

The rock dryer is a revolving sheet-iron drum carried on trunnions. There is a coal fire at the lower end and a chimney at the upper, with the heated gases passing through the drum from the fireplace to the chimney.

From the dryer the stone is elevated to bins which are set on a staging of steel work over the raw material mills. Of these there are nine, all 30-inch Griffin mills. In them the reduction of the raw material is completed. It passes from them directly by conveying and elevating machinery (see Figures 59 and 60) to the

bins at the rear of the kilns. Some 50 feet in the rear of this line of mills is another group of 12 Griffin mills, which are run on clinker, and are shown in Figure 62. Their setting, with bins on staging above and with conveyors below, leading to elevators, is similar to that of the other group of mills. Between the two groups of mills are the two shafts leading from the main engines, with the belt drives to each group. The driving belt of each mill has its own friction clutch on the line pulley, and any mill can be cut out by releasing the clutch. The overhead conveyors, carry-

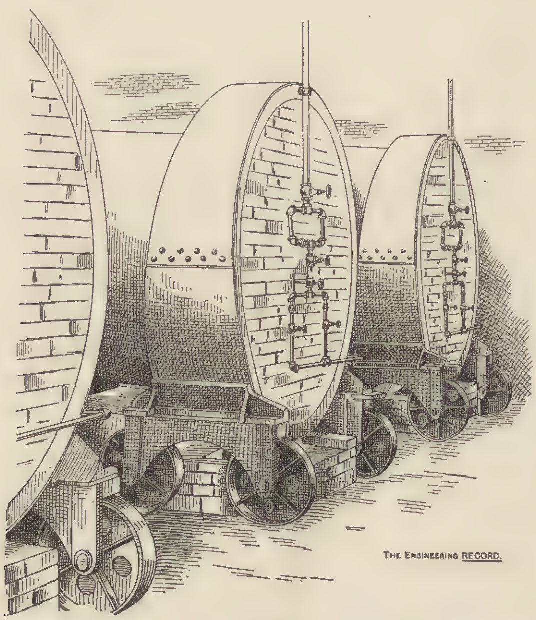

Figure 61.—End Housing of Kilns.

ing stone and clinker, are rubber belts. The conveyor to the stock house is shown in Figure 59, and there is a link belt drive leading over the bridge to the stock house for the purpose of driving the overhead conveyor distributing cement to the stock house bins. Whenever the cement mill is in operation these conveyors to and through the stock house are operated by the mill engine.

The Kiln Building.—This building is for the most part two stories high and has the kilns on the upper floor, some 16 feet

from the ground. There are six kilns, 60 feet long and 6 feet in diameter, narrowing to 5 feet 6 inches at the upper end. They were built by W. F. Mosser & Son, of Allentown, Pa., and are mounted and turned in the usual manner. All six kilns are driven by one 25-horse-power engine, set up on the ground floor below, and belted to a main shaft running under the kilns. From this line shaft there are link belts leading to countershafts which drive the train of gears ending in the pinion which en-

Figure 62.—The Cement Mill.

gages the rack on the body of the kiln. The same countershaft drives the feed screw from the raw-material bins. There is a change of speed provided for the countershafts by throwing in friction clutches on different drives. Any change of the speed of revolution affects also the feed of the raw material, so that the bed of raw material on the kiln lining is constant. The fuel used in these kilns has been oil, but this is soon to be replaced by coal. The end housing of the kilns is shown in Figure 61.

The six kilns discharge in pairs by chutes dropping the clinker

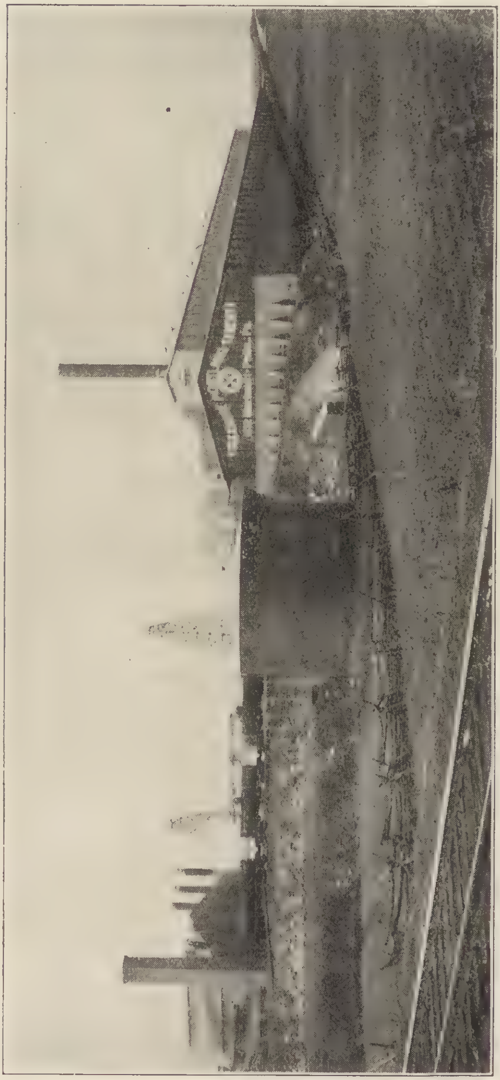

Figure 64.—View of the Stock House from the Railway.

into three elevator boots. It is elevated into three cooling tanks, as shown in Figure 60, which have an artificial circulation of air and discharge nearly cold clinker from chutes at the bottom. This clinker is cracked in two Mosser crackers and passes thence by elevator and belt conveyor to the cement mill.

The Stock House.—In size, capacity and cost this building is believed to be unique in cement manufacturing. It is a substantial brick and iron building, with slate roof, about 80 feet wide by 590 feet long, and will store 70,000 barrels of cement. It sets

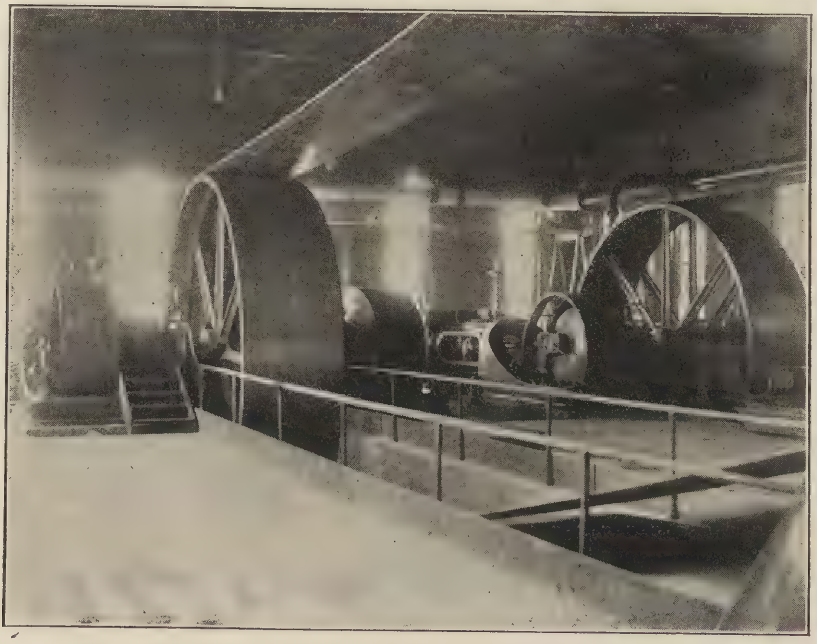

Figure 63.—Interior of the New Engine House.

on ground which has a natural slope to the east, and seen from that side, as in Figure 64, its great size is accentuated. It has 6-foot alleys on either side, with conveyor troughs set in the floor. Excepting a few transverse gangways, one of which contains barrel-packing machinery, the entire building between the side alleys is given up to cement bins.

All the buildings described above are of substantial brick and iron construction, with the exception of the stone house, which

is a steel skeleton building sheathed with galvanized iron. The power building, boiler house, stone house and kiln platform have substantial concrete floors. Taken as a whole, it may fairly be said that the plant is as genuine and substantial in construction as anything which has been built for Portland cement manufacture.

The writer is much indebted to Mr. J. B. Lober, vice-president of the company, and to Messrs. Stradley and Dunn, secretary and superintendent, respectively, for the opportunity to describe this plant for the readers of The Engineering Record.

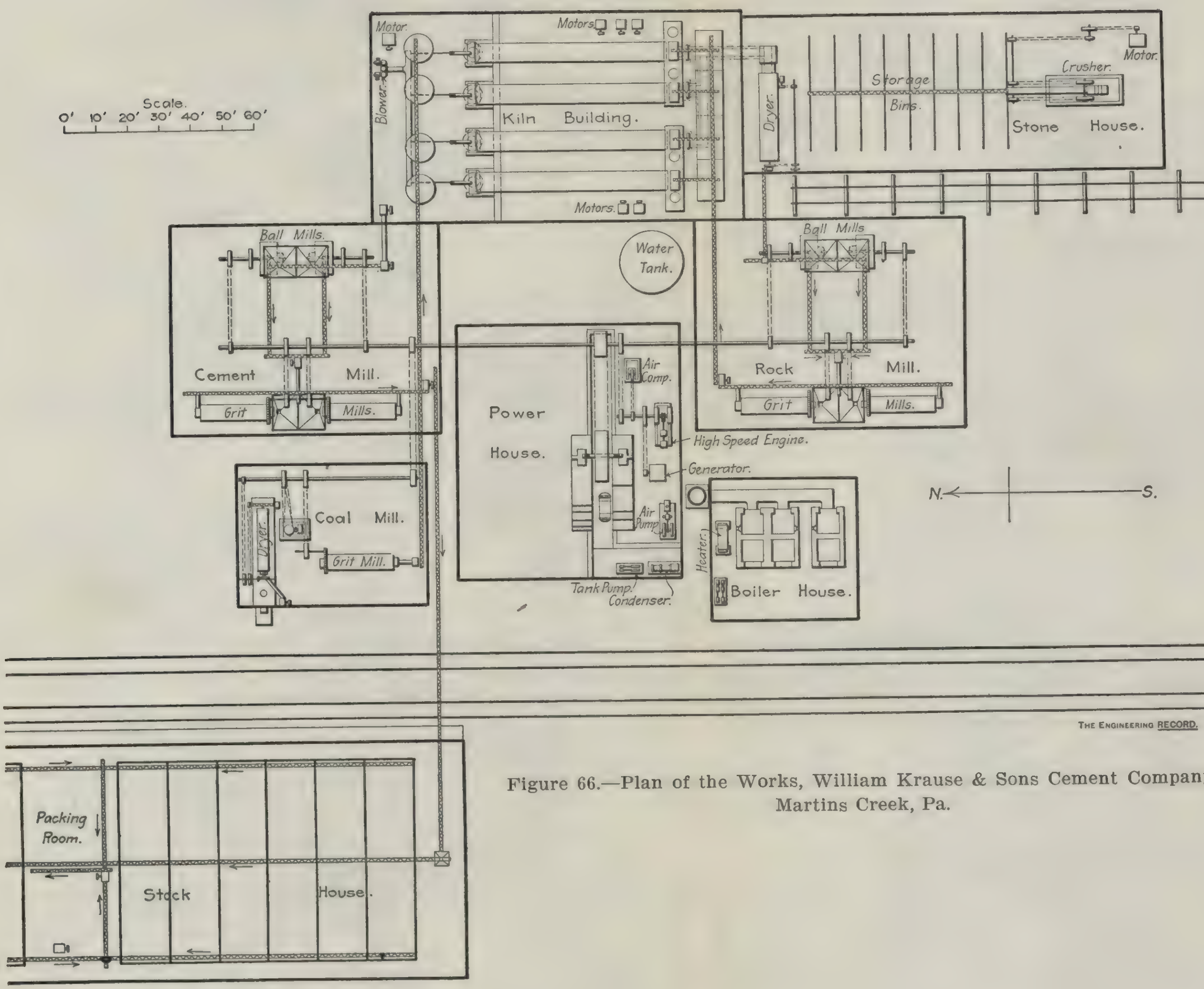

Figure 66.—Plan of the Works, William Krause & Sons Cement Company, Martins Creek, Pa.

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CHAPTER XI.—THE NEW WORKS OF THE WILLIAM KRAUSE & SONS CEMENT COMPANY, MARTIN'S CREEK, PA.

By Horace De R. Haight, C. E.

A modern cement plant, recently completed, is that of the William Krause & Sons Cement Company, situated at Martin's Creek, Pa., on the west bank of the Delaware River, about seven miles above Easton. The particular site selected for this plant is advantageous for many reasons. The Pennsylvania Railroad and the Bangor & Portland Railroad have the joint use of a railroad line running along the south side of the property. The plant itself is located on a flat of 10 or 12 acres, at the north end. Besides this flat, there are several acres in river and hill slopes, and the remainder of the property, consisting of from 18 to 25 acres, is a bold hill rising about 200 feet above the river. This hill is practically a solid mass of argillaceous limestone rock with a thin coating of soil. The rock is estimated to be sufficient in quantity to supply a large plant for many years. The company owns another stone tract adjacent to the Bangor & Portland Railroad Company, about a mile from the plant, where the minor ingredient for the product is obtained. Numerous and frequent tests covering a period of 3½ months of the deposit of stone located upon these properties were made by Messrs. Booth, Garrett & Blair, of Philadelphia, and as a result of their examinations and analyses it was found that the best quality of Portland cement could be obtained from the rock. The following is their report of the tests of the cement made experimentally from the raw materials found on the above mentioned property:

Fineness.—Passing No. 50 sieve, 100 per cent.; passing No. 74 sieve, 100 per cent.; passing No. 100 sieve, 100 per cent.; passing No. 200 sieve, 87 per cent.

Setting Time of Neat Cement.—Initial set, 1 hour. Final set, 3 hours 15 minutes. Percentage of water, 22. Temperature of air, 70 degrees Fahrenheit. Temperature of water, 65 degrees Fahrenheit.

Constancy of Volume Tests.—Normal pat tests (Am. Soc. Civ. Engrs.): Air pats (A), good; cold water pats (B), good. Accelerated tests: Hot air test (C), good, sound and hard; warm water test (Faija), good, sound and hard; boiling water test (Michaelis), good, sound and hard.

Tensile Strength of Standard Briquettes, 1 Inch Square. Hardening Period, One Day in Air and Six in Water.

| Proportions of mortar. | | | Strength, | Seasoning |
Cement.	Sand.	Per cent. water.	in pounds.	after calcination.
1	0	20	672	1 week.
"	"	"	634	"
"	"	"	630	"
"	"	"	650	"
"	"	"	632	"
			Ave. 644	"
1	3	10	285	"
"	"	"	308	"
"	"	"	280	"
"	"	"	262	"
"	"	"	285	"
			Ave. 284	"
1	0	22	804	2 weeks
"	"	"	867	"
"	"	"	876	"
"	"	"	846	"
"	"	"	760	"
			Ave. 831	"

The chemical analysis of the samples showed a composition as follows: Silica, 22.24 per cent.; alumina, 7.17; ferric oxide, 4.05; lime, 64.13; magnesia, 2.01.

The cement from which all of the above tests were made was manufactured from the ordinary run of raw material found upon the company's property.

Figure 65 is a map of the property upon which the Krause plant is located. The face of the limestone quarry is shown at AA. The quarry will be extended along the foot of the hill in either direction, as may become necessary. The figure also shows a plan of the buildings, which are designed for an output of 600 barrels per day. The plant is so designed that the buildings can be extended so as to increase the plant from four to twelve rotary kilns without interfering with the operation of the machinery at present installed. The dotted lines show the direction in which the extensions will take place. The buildings are of the following dimensions: Stock house, 75x250 feet;

boiler house, 45x46 feet; coal mill, 45x60 feet; power house, 70x80 feet; rock mill, 66x85 feet; cement mill, 66x85 feet; stone house, 49x130 feet; kiln building, 66x117 feet; office building, 25x42 feet. The floor elevations of all the buildings are the same, except that of the stock house, which is 6 feet above the others. The kiln building is a steel structure and the stock house walls are litholite with a timber roof. The litholite walls of the stock house are hollow and the method of constructing the litholite blocks is patented by the owners of the plant. The remaining buildings were originally designed to be of steel, but the inability to secure the material rendered it necessary to construct them with substantial wood trusses on brick walls.

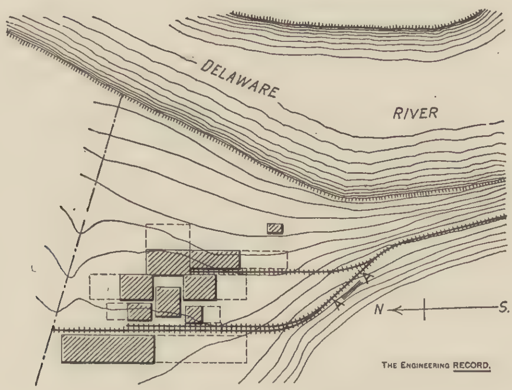

Figure 65.—Map of Works.

Figure 66 is a large plan of the works, showing the machinery in the various buildings. Stone from the quarries is brought in cars on a trestle and dumped on to the floor of the stone house, or it may be stored underneath the trestle, in bins provided for the purpose. The proper proportions of the lime and cement rock necessary to give the desired composition in the finished product having been determined by chemical analysis, the raw materials are mixed in the proportions found necessary and dumped into a crusher from which the mixture is elevated to a screw conveyor depositing the crushed material in the storage bins shown in the drawing. From these storage bins the material is wheeled to an elevator which drops it into a Ruggles-Coles dryer, situated in the north end of the building. This

dryer was described in detail in The Engineering Record of December 17, 1898. The stone is dried by the waste gases from the rotary kilns, the gases passing from the kilns to the dryer through an underground duct. After passing through the dryer, the waste gases are exhausted by a centrifugal blower that has sufficient exhausting effect to maintain the proper draft through the kilns. The amount of gas passing from each kiln is regulated by means of dampers. If the drier is not in use, certain dampers may be closed and others opened, caus-

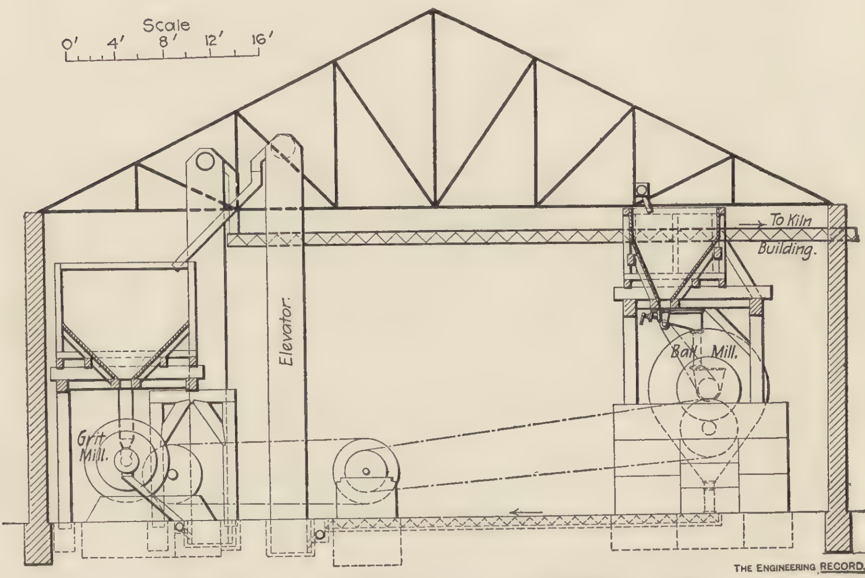

Figure 67.—Cross-Section of the Raw-Material Mill.

ing the waste gases to pass out through the usual kiln stacks. After the stone is thoroughly dried it passes directly from the dryer to an elevator and a system of conveyors that finally deliver the material to a large stock bin situated over two Krupp ball mills located in the raw-material mill building, where it is partially ground. From the ball mill the material passes to an elevator by means of a right-and-left screw conveyor, and from the elevator it falls by gravity into a tank situated over Krupp grit mills, through which the material is next passed.

Figure 67 is a cross section of the raw-material mill and shows

the machinery just described. The finely ground product is elevated from the tube mills into a screw conveyor which carries it to the steel storage tanks in the kiln building, above the upper end of the rotary kilns. The kilns are of usual construction, 6 feet in diameter and 60 feet long, and have a pitch of one-half an inch per foot. They are driven by independent electric motors, and their speed may be varied through a wide range in a manner that will be described later. The raw material is fed into the kilns from the tanks by means of short screw conveyors, which are operated by means of an electric motor located at one side of the kiln building. The burned clinker falls into a clinker cooling pit at the north end of the kiln building, and it is there cooled; after this it is placed in an elevator connecting with a conveyor which carries the burned clinker to the cement mill. The machinery in this building is a duplicate of that in the raw-material mill, and the treatment of the clinker is the same as the treatment of the raw material. The finished cement is elevated to a belt conveyor which carries it across a bridge, where it is distributed by another conveyor into the bins in the stock house for storage. This building has a storage capacity of about 35,000 barrels. When the material is to be packed it is carried by conveyors at either side of the stock house to a central point, where it is elevated to a distributing bin which is directly connected to the bag and barrel packers. The stock house also contains a cooperage department.

Coal is used for fuel for all purposes; a railroad track extends along the west wall of the boiler house and the west wall of the coal mill, and in the latter the coal is pulverized for use in the rotary kilns. The coal for the mill is dumped into bins underneath the track, the track being built upon a trestle, and from the bins it is shoveled into an elevator, which carries the coal from a point outside the building to a chute leading to a Cummer dryer. After being dried it is conveyed to a Mosser crusher, from which it is elevated to a storage tank over a tube mill, where it is finally pulverized. From the tube mill the coal is elevated and conveyed to steel storage tanks in the kiln building. The bottom of each of these tanks has an opening through which the material is fed into a screw conveyor which forces the material into a blast pipe connected with the end of the kiln. The coal burner used in this plant was designed

and patented by the chief engineer, Mr. Frederick H. Lewis, M. Am. Soc. C. E. The low-pressure air blast is supplied by a small pressure blower operated by means of an electric motor, and the high-pressure by an air compressor located in the engine room. The arrangement of the kilns, coal tank, etc., is shown by Figure 68, which is a partial longitudinal section of the kiln building.

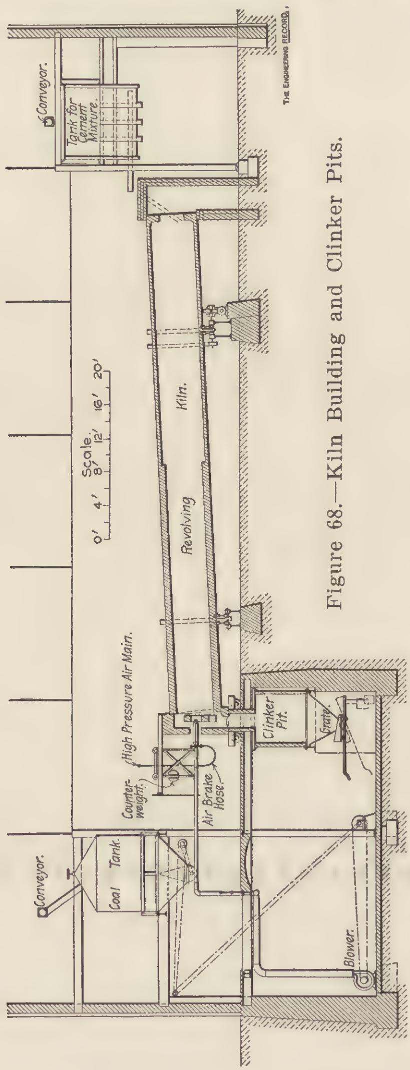

Figure 68.—Kiln Building and Clinker Pits.

Steam for the plant is supplied by three 250-horse-power Babcock & Wilcox boilers. Power is supplied by a 600-horse-power cross-compound condensing engine of the Corliss type, made by the E. P. Allis Company, of Milwaukee, Wis. The steam pressure used is 135 pounds. The engine is belted directly to a line shaft that extends into the cement mill and rock mill, and the machinery in these buildings is driven by belts leading directly from pulleys on this main shaft. The coal mill is driven by a belt from this same shaft. A considerable part of the power required in the plant was used in the three buildings mentioned. The stone house, kiln building and stock house required a

total of not over 150 horse-power, and the demand for power in the stock house would not always occur. The kiln building and the stone house, on the other hand, had to be run night and day, and in view of the fact that the kiln building and the stone house and stock house could not be driven from the main shaft by means of belts, it was decided to operate these three buildings by means of an electric system of distribution. For this purpose a jack shaft was located in the engine room, and the electric generator installed so as to be driven by a belt from this jack shaft. The jack shaft was connected to the main shaft by means of a belt and friction clutch and also directly connected to a 150-horse-power high-speed engine made by the Ames Iron Works. The engine was connected to the jack shaft by means of a clutch also, the intention being to drive the dynamo from the main engine when it was in operation, and to disconnect the generator from the main engine when the latter was not in service, and to drive it then by means of the high-speed engine. This smaller engine was provided with two cylinders, it being supposed that the compound principle would not only work better with the high steam pressure used, but that a considerably greater economy would be attained than if a simple high-speed engine had been installed. A small air compressor supplying air to the coal burners or the kilns is also belted to the jack shaft in the engine room. A large compressor of Ingersoll-Sergeant make drives the rock drills in the quarries. The generator supplying electric light and power supplies a number of arc and incandescent lights about the grounds and building and also various electric motors in the buildings mentioned. The generators and all of the motors throughout the plant, except three driving rotary kilns, and located in the kiln building, are of Westinghouse make. Direct current at 220 volts is used. Three motors in the kiln building are of Crocker-Wheeler make. An unusual method of driving the kilns by the use of motors, shown in Figure 69, is employed. The motors are of the ordinary compound-wound type and are capable of being varied in speed about 15 per cent. either side of the normal by varying the field resistances. Suitable bearings are attached to the base of the motor, and in these bearings a secondary shaft, marked B in the figure, is placed. The armature shaft is connected to the shaft, B, by means of the pair of gears,

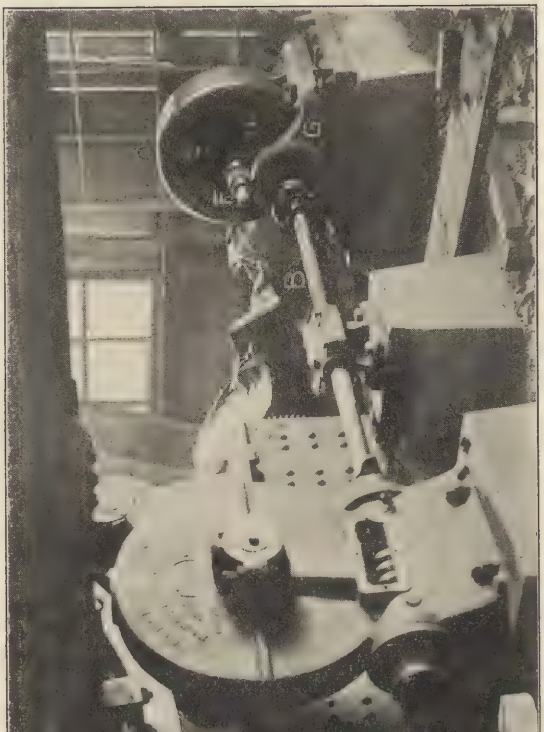

Figure 69.—Attachment of Motor to Kiln.

F and G, shown in the figure. The armature shaft is free to move back and forth a few inches in a longitudinal direction. There are a similar pair of gears at the other end of the motor; one connected to the armature shaft and one to the shaft, B; but these two gears cannot be connected unless the armature shaft is moved longitudinally so as to disconnect the gears, F and G. The relative diameters of the two sets of gears are such as to give, with the variation in speed in the armature shaft due to varying the field resistance, a variation of speed to the shaft, B, of over 100 per cent., and of practically all intermediate speeds between the highest and lowest speed that it is possible to attain. All of the motors in the kiln building are enclosed by a box-like covering to protect them from dust and yet allowing enough space to be repaired. The Westinghouse motors that are located in places where they are likely to become covered with dust or cement are also enclosed.

The shaft, B, driven by the motor, is connected to a Hindley worm gear made by Morse, Williams & Company, of Philadelphia. The speed of the motor is still further reduced by this gear. The worm is enclosed in a tight casing and is thoroughly flooded with oil to ensure proper lubrication. The worm gear drives a small spur gear which meshes into a larger gear fastened to the periphery of the kiln.

The main engine is run condensing, and to obtain condensing water a trench was dug from the river to a well that was placed a short distance from the engine room, and in the bottom of the trench a 12-inch sewer pipe was laid, thus connecting the river with the well. A cast-iron pipe was run from the well to the condenser, which is of the jet type, and made by the Stilwell-Bierce & Smith-Vaile Company. This was located in a pit in one corner of the engine room, so that the total lift on the condenser, at the lowest known level of the river, is not over 20 feet. A tank pump was connected to the suction pipe of the condenser so that water could be drawn through it and pumped into an elevated tank from which the water supply is obtained. The boiler feed pump was connected so that it could draw water from the elevated tank or from the suction pipe of the condenser. All the auxiliaries of the plant—that is, the feed pump, tank pump, the steam-driven air compressor and the lighting engine—are all run non-condensing, and as much

of the exhaust steam as possible is utilized in a feed-water heater.

The officers of the William Krause & Sons Cement Company are Mr. Bernard J. Krause, president; William Krause, vice-president; Joseph F. Rose, secretary and treasurer; Frederick B. Franks, general manager. Mr. Frederick H. Lewis, M. Am. Soc. C. E., was the chief engineer, and Mr. Horace DeR. Haight, C. E., was resident engineer.

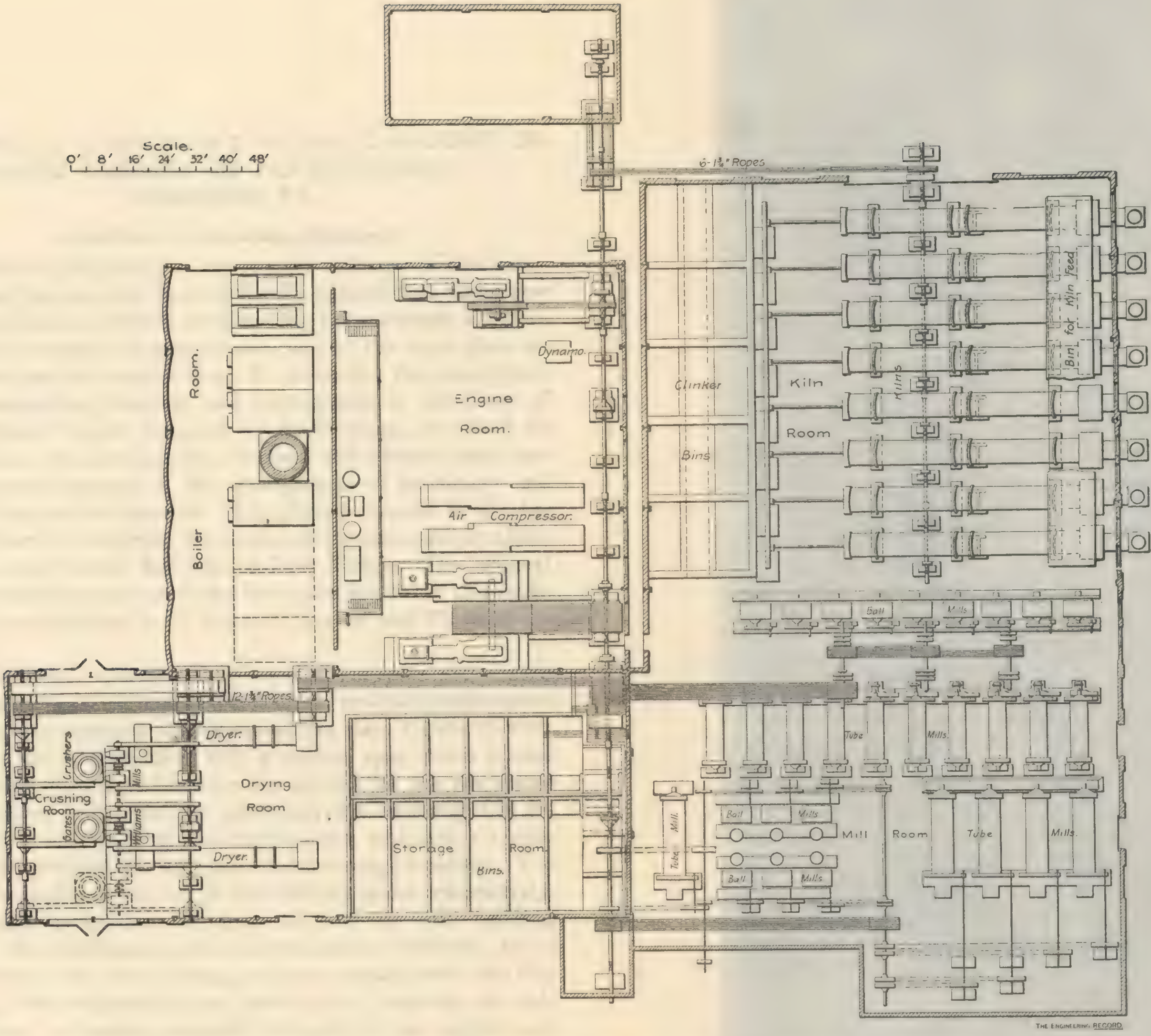

Figure 70.—Plan of the Mill, Lawrence Cement Company of Pennsylvania, Siegfried, Pa.

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CHAPTER XII.—THE PLANT OF THE LAWRENCE CEMENT COMPANY OF PENNSYLVANIA, SIEGFRIED, PA.

By Lathbury & Spackman, Engineers.

With the rapid growth of the cement industry in this country during the past ten years, it is only natural that many new methods should be evolved for handling the materials and simplifying the method of manufacture and at the same time reducing the cost of manufacture. In presenting this description and accompanying drawings and photographs of the plant of the Lawrence Cement Company of Pennsylvania, we think all interested in the manufacture of cement will observe many new and improved features in the arrangement of machinery and the handling of the materials. The plant is located in the Lehigh District at Siegfried, Pa., about seven miles above Allentown, on the Central Railroad of New Jersey. The original plant located here was one of the first mills erected in this country, and manufactured both hydraulic cement and Portland cement.

The buildings, constructed of steel framework with brick sides, are fireproof throughout and of an unusually substantial character. As shown by the accompanying plan, Figure 70, they consist of the long building with a 64-foot span which houses the crushing, drying and milling department for the raw materials, together with grinding machinery for finishing the cement; and connected with it at right angles, and having a span of 120 feet, is shown the kiln and clinker-storage building. The engine and boiler house, of 75 and 42-foot spans, respectively, run parallel to the kiln building and join the mill building proper. The stockhouse, with a clear span of 120 feet, is located north of the mill building, and runs parallel with the kiln building. The fuel building for grinding and preparing the pulverized coal is located alongside the end of the engine and boiler house and runs parallel with the main building.

The natural slope of the ground offered great advantage for

Figure 71.—Method of Mining Cement Rock.

the designing of a plant whereby a gravity system could be utilized for moving and handling the rock at the raw-material end and for the storage and handling of coal. The buildings throughout were designed in order to allow for extension in any department, and, with the exception of the kiln building, provision has been made in present buildings to install further grinding and crushing machinery in both the raw-material and finishing cement departments. In the engine room provision has been made for 2,000 horse-power additional, while the boiler room will accommodate a further increase of 1,000 horse-power.

In the design of the steel work for the building, with the exception of the stockhouse, the roof trusses are carried on steel columns encased in brick walls, while in the stockhouse the roof truss is carried on reinforced pilasters at each bay in the brick walls. Throughout the construction the idea was carried out to provide clear spans for all buildings, and there are no columns rising from the centers of the floor spans in any of the buildings. The kiln, engine, boiler and fuel buildings were covered with 24-inch porous terra-cotta tile supported on T's, which in turn rest on the roof purlins. On this tile the slate covering was nailed in order to prevent any liability arising from fire, and thus providing a practically fireproof construction. The roofs of the other buildings were constructed of 2-inch hemlock sheathing on which was nailed the slate covering. At the gable ends of the buildings, which are liable to be extended for future increase, arches have been constructed in the brick walls and afterward bricked up so that at any future time these blind arches can be opened up and the rooms for each department made continuous. Where drops in the ridge levels occur the gables are covered with corrugated iron. The east wall of the boiler room was constructed of concrete, and arches having a radius of 43 feet were thrown between the supporting columns for the roof trusses. These arches resist the thrust of the coal and the resultant strain is transmitted to the steel work at right angles to the direct thrust of the coal, thus avoiding the necessity of having a heavy retaining wall at this point.

The material from which the cement is manufactured is the argillaceous limestone of the Lehigh region commonly known as cement rock, to which is added, for Portland cement, comparatively pure limestone, in order to produce the proper chemical

composition of the raw mix. The large limestone quarries, owned exclusively by the Lawrence Cement Company of Pennsylvania, are located on the Central Railroad of New Jersey, about four miles south of the site of the plant. The limestone is conveyed to the plant over the Central Railroad of New Jersey in specially constructed side dump cars, and these cars are then handled in the yards of the cement plant by a locomotive belonging to the company.

The argillaceous limestone or cement rock underlies the entire property on which the plant is located, extending from the Lehigh River across and under the tracks of the Central Railroad of New Jersey, back to the bluff along the Hokendauqua Creek, about three-quarters of a mile. The quarries have been opened up along the bluffs on the banks of the Hokendauqua Creek, and, as shown in one of the photographs, Figure 71, the rock is mined, thus avoiding the great expense of surface stripping. The lower levels of the mine are reached by an inclined plane with double tracks constructed in tunnel, although only one tunnel is at present used. The galleries of the mine open out along the bluff on the banks of the creek, at which point along the face of the bluff the quarry was opened up and developed some years ago.

The cement rock was formerly carried to the upper levels in cars by means of a hoist and inclined plane located on the outside of the bluff. The mine equipment at present used is most complete, and the drills, hoisting machinery, etc., are operated by compressed air, the compressors for which are located in the engine room. At the top of the bluff, on the upper level, is located the building in which is installed the hoisting engine for operating the quarries. The track in the tunnel has an ascending gradient of 20 per cent.; and after reaching the mouth of the tunnel there is a descending gradient of 2½ per cent. to the crusher building. This permits the loaded cars (if found necessary) to be run down to the crusher building without the aid of a locomotive.

Briefly described, the process of manufacture for the Portland cement is as follows: The cement rock is loaded in the mine on specially constructed side-dump steel cars, owned by the company, and they are then drawn up the incline to the locomotive, which awaits them at the mouth of the tunnel on the

upper level. The cars are then run down to the mill without rehandling the material, which is afterward dumped directly from the mine cars into the Gates crushers. The latter are located side by side between the double tracks which enter the building, supported on steel trestle work. Large doorways are located on either side of the building, thus making the two tracks continuous through the buildings, and passing on out at the

Figure 72.—Arrangement of Gates Crusher and Williams Mill.

south end on the wooden trestle under which the coal is stored. The limestone is brought into the mill on one track, while the cement rock is brought in on the other. The materials are ground separately in the Gates crushers and pass from the crushers into a battery of four Williams mills, located directly in front of and at a slightly lower level than the crushers, as shown in

Figure 72. These disintegrators reduce the crushed stone to the consistency of a coarse grit.

From the Williams mills the material is conveyed directly into the two rotary dryers, where the moisture is completely driven off by being exposed to the direct heat in the cylinder. The material, after passing through the dryers, is elevated and carried by overhead conveyors into two rows of storage bins for raw material only; the ground and dried limestone being kept entirely separate from the cement rock in the bins. These bins are constructed of wood with hoppered bottoms, and have a capacity of raw material sufficient for two weeks' supply. (See Figure 73.) While the material remains in storage it is subject to careful analyses, in order to ascertain the exact chemical composition of each bin. Located directly under the center partition line of the two rows of bins is a brick-arched tunnel, having sufficient head room for a man to walk upright. In this tunnel, and running the entire length, are two lines of conveyors located on the floor, and abutting against the sides of the tunnel. Automatic doors, operated by a trip, open up from the floor level of the bins directly into these conveyors, and the material flowing out from the bins is picked up by the screw conveyors and carried to the elevators located at the far end of the tunnel. At this point the material is raised by two elevators and discharged directly into hoppers which feed the automatic scales, located slightly above the lower cord of truss and supported upon platforms which in turn rest directly on the raw-material bins. These automatic scales, manufactured by the Pratt & Whitney Company, carefully weigh and proportion the two raw materials in order to form a correct mix.

From the automatic scales the raw mix, now correctly proportioned, is conveyed and elevated into the hopper of Smidth ball mills, of which there are six. Two of these mills may be used in reducing natural cement, as will be afterward explained. From the ball mills the raw mix is passed through Smidth tube mills, there being four of these, and from the tube mills is conveyed to the kilns.

There are eight bins located at the rear end and over the rotary kilns, each bin having sufficient capacity for supplying one rotary kiln for a period of 48 hours. The raw material is carried by conveyors and thence through water-jacketed chutes directly into

the rotary kilns. The material, while passing through the kilns, is subjected to the intense heat obtained by burning finely powdered coal mixed with air, which is forced into the kilns at the discharge ends. The clinker, after discharging from the kilns,

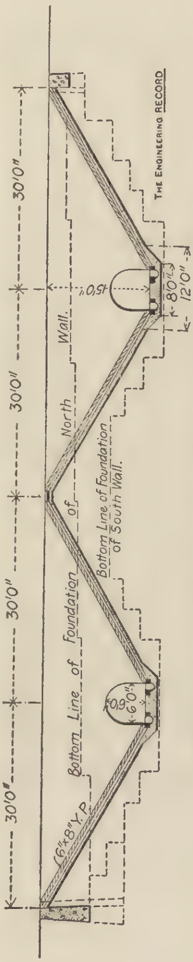

Figure 74.—Section Through Floor of Stock House.

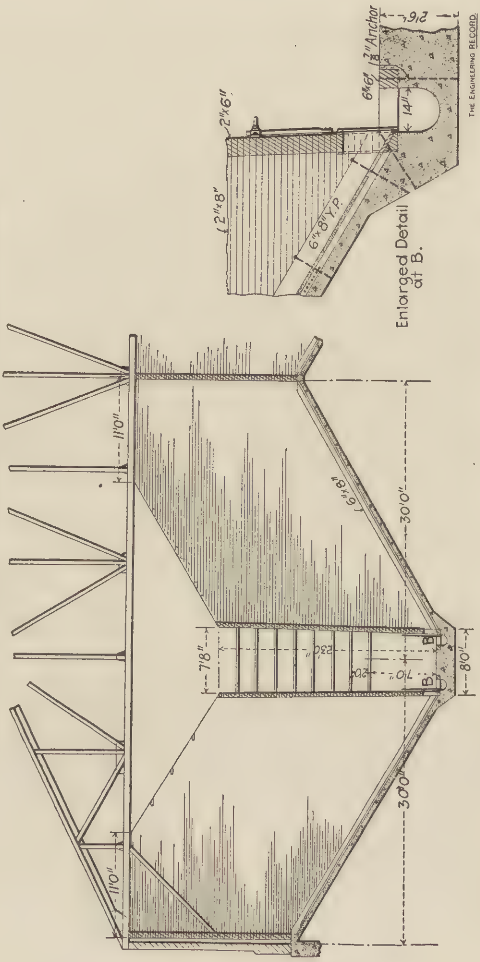

Figure 73.—Half Section Through Raw-Material Storage Building.

drops into heavy double-strand open elevators; one elevator is provided for each pair of kilns and the clinker is raised by this elevator and dropped on to a double-line Simpson conveyor, located over the cooling bins, which carries it either to the right

or left, discharging into any or all of the bins as occasion may require. These bins, constructed of brick masonry, have a capacity of 20,000 barrels of cement and have an arched passageway running underneath the entire length. The clinker is cooled in the bins by an air blast driven up into each bin from the system of piping which is located along the arched roof of the tunnel. In this arched tunnel, as in the one previously described under the raw rock bins, ample head room and width is provided for workmen to pass in and out in order to adjust or repair the bin doors or conveyors.

The bins are of hopper construction and so arranged that the cooled clinker at the bottom is discharged through chutes provided with automatic doors on to a belt conveyor in the tunnel, which carries it to elevators at the end of the tunnel, from which point it is raised and discharged on to a Simpson conveyor, located directly over and discharging into the bins which feed the battery of Smidth ball mills. The clinker is reduced in the ball mills to such a fineness that it will pass a 30-mesh sieve, and is then carried by the line conveyor, located underneath the battery of mills, to an elevator which raises it and then discharges it either into a conveyor which carries it direct to the bins located over and feeding the tube mills, or to an auxiliary conveyor running to the automatic weighing and mixing apparatus, where the clinker is weighed and proportioned when a second-grade Portland or an improved cement is desired. From this mixing apparatus the second-grade Portland or improved clinker is then returned to the conveyors located over the bins supplying the Smidth tube mills. By this arrangement, it is possible to operate the tube mills on the highest grade of Portland cement one day, and the next day operate the Smidth tube mills for a second-grade Portland or improved cement. The material after passing through the Smidth tube mills discharges into an underground conveyor, located below the battery of tube mills and is carried to the end of the mill room, where it is elevated and discharged into either one of the pair of screw conveyors which carry it directly to the stockhouse. These twin conveyors are at present temporarily supported on trestle work between the mill building and the south end of the stockhouse, because only one-half of the stockhouse has been constructed. When completed the south end will extend within 20 feet of the mill building. At present

the stockhouse has 72 bins, with an aggregate capacity of 125,000 barrels of finished cement, and when the other half is completed will have one of the largest, if not actually the largest, capacity in this country. As arranged, the storehouse has two aisles with

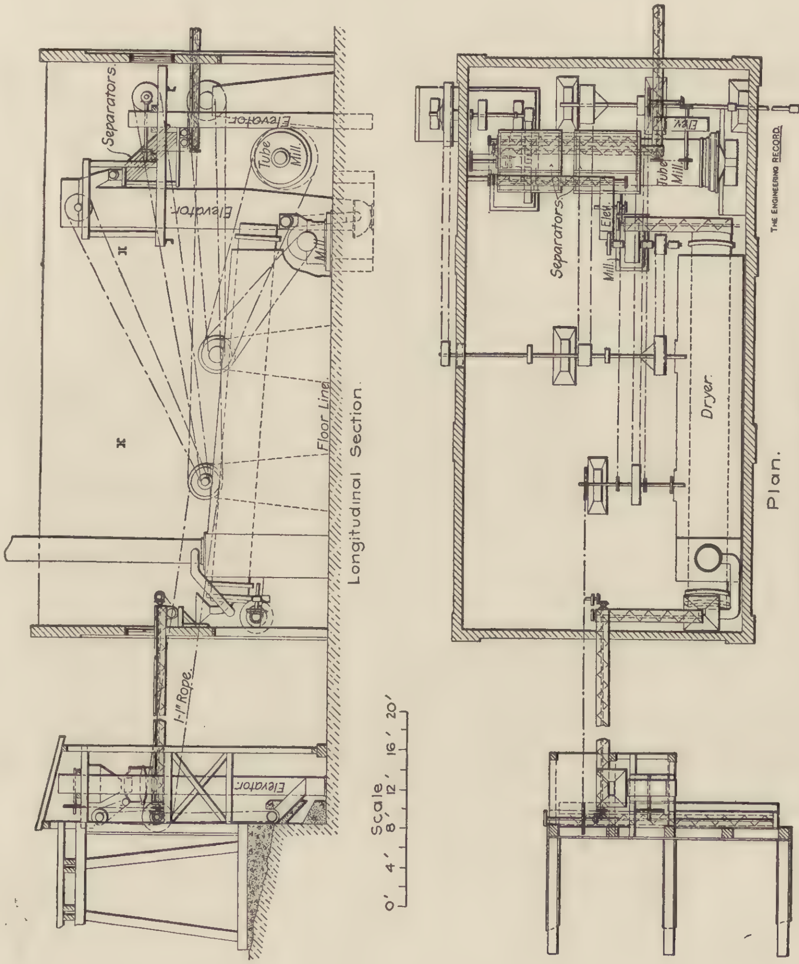

Figure 75.—Coal Mill.

four rows of bins, and the overhead conveyors for distributing the cement from the mill room are so arranged that two grades of cement can be manufactured at the same time, and carried from the mill room and thence distributed into any line of bins

for storage and seasoning, previous to its shipment. See Figure 74.

The seasoned cement is hoppered out from the self-discharging bins through automatic doorways directly into the screw conveyors which rest on the floor in the passageways. These conveyors carry the different grades of cement to the north end of the building where the spacious and well-equipped packing department is located.

This department of the stockhouse is provided with two stories, and the second floor so designed that it will carry a safe load of 300 pounds to the square foot. On this floor the large stock of burlap and paper bags is carried, together with the motors which operate the packing machines and elevators. The first floor is devoted exclusively to the packing of the cement in barrels, burlap and paper bags, storage room also being provided for a considerable supply of packed cement.

The coal for burning the cement is stored in coal pockets constructed underneath the high wood trestle supporting the double track, which, as has been mentioned, passes through the east end of the mill room and between the two crushers. These coal pockets are so arranged that the hoppered bottom coal cars are pushed through the mill building and out on the trestle and the coal discharged directly from the cars into them, from which it is drawn by gravity and discharged into the conveyor running along the front of the concrete retaining wall. The coal is then carried to a point directly in front of the end of the fuel building, where it is elevated and discharged into an automatic weighing and registering machine, by which means careful figures are kept of the actual coal consumption for the burning of the cement in the kilns. (See Figure 75.) From the weighing machine the coal is conveyed into the building and discharged directly into the rotary coal dryer. After passing through the dryer, the coal then carrying on an average less than 0.5 per cent. moisture is discharged into the Williams mill, where it undergoes preliminary disintegration. It is afterward pulverized to the proper degree of fineness in a 20-foot Smidth tube mill specially constructed for coal grinding. The powdered dry coal is then conveyed into the coal building and discharged into the eight bins located directly in front of the kilns and from which it is fed by an air blast into the kilns.

The coal used for boiler purposes is stored in coal pockets similar to those used for the coal which burns the cement, but on the same line of trestle back of the boiler house. The front wall of the coal pockets for boiler purposes is the arched concrete east wall of the boiler house already described. The coal banked up against the arched wall flows through the large iron frame doorways, two in each arched bay, directly on to the boiler-room floor.

Although no mechanical stokers are at present used, provision has been made and they are to be installed in the near future.

In addition to the manufacture of Portland cement, as previously described, there are six vertical kilns for the manufacture of natural cement. These kilns are so arranged that the mine cars are run directly from the quarry and, by means of trestle work supporting double tracks, pushed into the steel housing constructed on top of the kilns, where the rock is discharged from the cars into the kilns. The coal is conveyed and elevated directly from the storage bunkers and fed into the kilns, alternate layers of coal and stone being used. After burning, the clinker is drawn from under the masonry arched openings in the base of the kilns, loaded on cars and then pushed a short distance to the mill, discharging the burned rock into a small Mosser crusher. After proper reduction by the crusher, the calcined rock is then conveyed and fed into two of the previously described ball mills used for grinding the raw material; it is then ground in a tube mill and is conveyed, as mentioned, to the stockhouse and there distributed in the bins for seasoning.

Throughout the mill, with the exception of the bins for the storage of raw material and the bins for the finished cement in the stockhouse, which are constructed of wood, steel construction has been utilized and the steel bins are either resting on masonry supports or framework of structural steel. The idea has also been carried out to use, as far as possible, the least amount of timber in the erection and supporting of the conveying and elevating machinery, while the majority of the shafting rests on masonry or steel framework supports, thus reducing to a minimum liability arising from fire.

In addition to the buildings already described wherein the cement is properly manufactured, a number of auxiliary buildings

have been erected which makes the plant most complete in itself. One building has been erected which contains a blacksmith shop, machine shop and storehouse, while a large cooper shop has been provided north of the packing-house end of the stockhouse in which the latest cooperage machinery has been installed. Adjacent to the cooper shop are several large storage sheds for cooperage material, wherein the stock can be thoroughly seasoned.

Facing the west sides of the kiln building and machine shop and located between the tracks of the Central Railroad of New Jersey and the mill buildings, a large and commodious brick office building has been erected. This office building contains complete chemical and physical laboratories together with offices for the clerical force at the mill; a number of sleeping rooms have also been provided for officers of the company who may visit the plant and desire to remain over night.

The power plant, as at present installed, consists of one cross-compound condensing engine of 1,200 horse-power, and one tandem condensing engine of 175 horse-power. These engines were furnished by C. & G. Cooper & Company, of Mount Vernon, O., and there is also one 400-horse-power Ingersoll-Sergeant air compressor, which is used for furnishing the power to the quarries. The boilers, six in number, are of the horizontal water-tube type, arranged in three batteries of two units of 250 horse-power each; these were manufactured by the Aultman-Taylor Machinery Company, Mansfield, O. Between engine and boiler house and running along the east wall of the former is located a pit 11 feet wide and 15 feet deep, in which is arranged the piping layout, together with the condensers, heaters, hot well, pumps, etc. This feature has the advantage of leaving the engine-room floor free of these accessories, and at the same time providing ready access to them for repairs and adjustment. The condensers are of the surface type and the condensed steam utilized for boiler-feed purposes.

In the engine room a complete electrical lighting and power plant has also been installed, including a 75-kilowatt generator, which, in addition to providing the current for the arc and incandescent circuits throughout the plant and grounds, also furnishes current to operate the motors located in the cooper shop, packing room and machine shops, these motors being used to drive the light auxiliary machinery contained in the various de-

tached buildings and the packing department, where line transmission of power is not provided.

Work was commenced and the ground broken for the erection of the plant, October 20, 1898, and the first cement was burned in October, 1899. It is somewhat difficult for a casual observer to grasp the extent and magnitude of the work involved and the material furnished in the erection of this plant, but some idea may be gained by referring to familiar units of construction. The buildings cover an area of practically 3 acres, and this includes only the actual floor space under roof. There were used in the construction of the plant over 3½ million bricks and over 1,000 tons of steel structural work, which does not include the machinery.

In the event of the plant being doubled, it will necessitate the extension of only a few of the buildings, while in others provision has been made for this increase and the machinery has only to be set on foundations, some of which have already been built.

Probably the most striking feature of the plant is the small number of men required to operate the mill on its full capacity; machinery has been substituted wherever possible to eliminate manual labor, and from the time the rock is loaded on the cars in the quarries, until the finished cement is packed ready for shipment, it is not once moved by hand. The only labor employed in the mill proper is that necessary for operating the various machines and looking after their proper adjustment, therefore this plant probably approaches nearer the term automatic in the manufacture of cement than any yet erected in this country.

In the shafting arrangement for the transmission of power a number of complex problems were presented. The bearings throughout the plant are ring oiling, and provision has been made for disconnecting the different departments on the main lines. The rope drive throughout the plant is on the single-rope system, and all the grooves are accurately turned in the sheaves, thereby insuring proper working of each rope. The power is transmitted between the main line shafts by rope while the various machines are driven from the auxiliary shafts by belts. All the machinery for the transmission of power was furnished by the George V. Cresson Company, of Philadelphia.

Throughout the design of this plant it was the aim, not

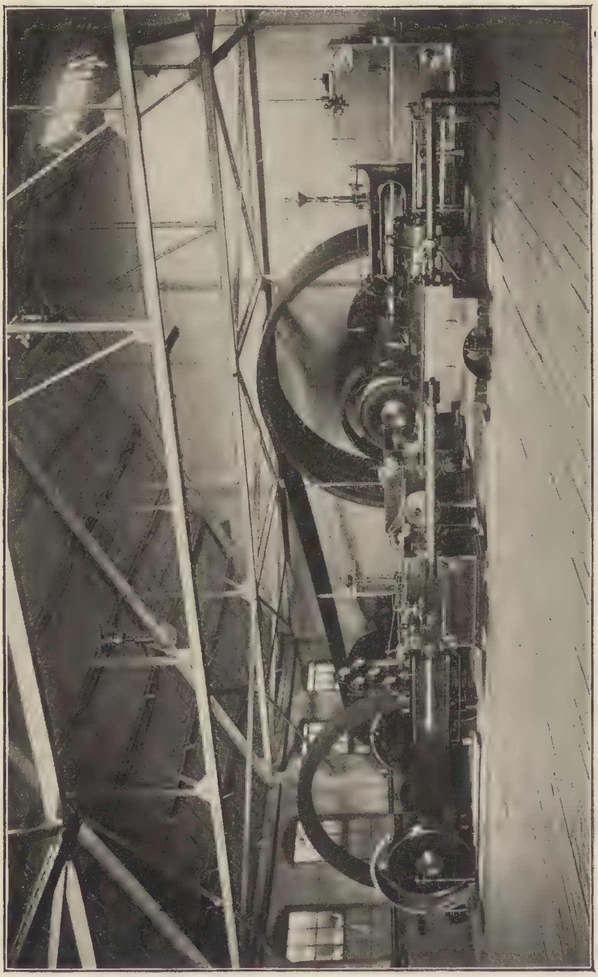

Figure 76.—View of Main Engine and Air Compressor.

only to introduce, as far as possible, even at a considerable cost in the installation, every known mechanical device for rapidly and efficiently handling the materials, but also to duplicate as far as possible such apparatus in order to avoid delays and shut-downs arising from the breaking of any special parts. The wise and liberal policy of the Lawrence Cement Company of Pennsylvania is not only indicated in this feature, but also in the general construction throughout the plant, which includes the best and heaviest materials.

It is well known to those interested in cement manufacture that there is probably no industry in which the wear and tear on the machinery and apparatus generally is so great, and in which the maintenance charges are such a large percentage of the cost of manufacture, and with these facts in mind the management desired the design and construction of a plant which would not only produce cement at the lowest possible cost but one which would show economy in the cost of maintenance and repairs. In this respect we think the Lawrence Cement Company of Pennsylvania can justly claim the distinction of having a model plant.

CHAPTER XIII.—THE VIRGINIA PORTLAND CEMENT COMPANY'S WORKS, CRAIGSVILLE, VA.

By Watson Vredenburgh, Jr., C. E.

The works of the Virginia Portland Cement Company, recently completed, constitute a Portland cement plant thoroughly modern in every particular of design and construction. The company is intimately associated with the Warren-Burnham Company, of New York, which has been identified for many years with the general construction work of the country.

The property of the company comprises about 1,200 acres, is situated at Craigsville, Augusta County, Virginia, on the main line of the Chesapeake & Ohio Railroad, and about 25 miles from the county seat, at Staunton. The accompanying map shows the immediate site of the plant, which is located on a flat of about 25 acres, directly adjacent to the railroad, surrounded by low hills, and further back, by the higher ridge of the Alleghany Mountains. As a site for a manufacturing plant, the land is regarded as an excellent location, having an abundant supply of good water near at hand.

The raw materials are obtained from fossiliferous limestone beds of the silurian formation, exceptionally well developed and very pure, and deposits of clay shales; both formations being admirably adapted to the operation of open quarries. A thorough research to determine the availability of the rock deposits for the manufacture of Portland cement and of the property as a site for the economical production of this product was made by the chief engineer, Mr. F. H. Lewis, M. Am. Soc. C. E., then of the firm of Booth, Garrett & Blair, of Philadelphia, and Mr. Charles Catlett, geologist. In connection with this research many samples were taken from which analyses and tests were made, covering in detail large sections of the country and long periods of time. So thorough has been this investigation and so satisfactory in results that the management is convinced of the presence of raw materials more than sufficient in extent and equally sufficient in character to enable them to manufacture in-

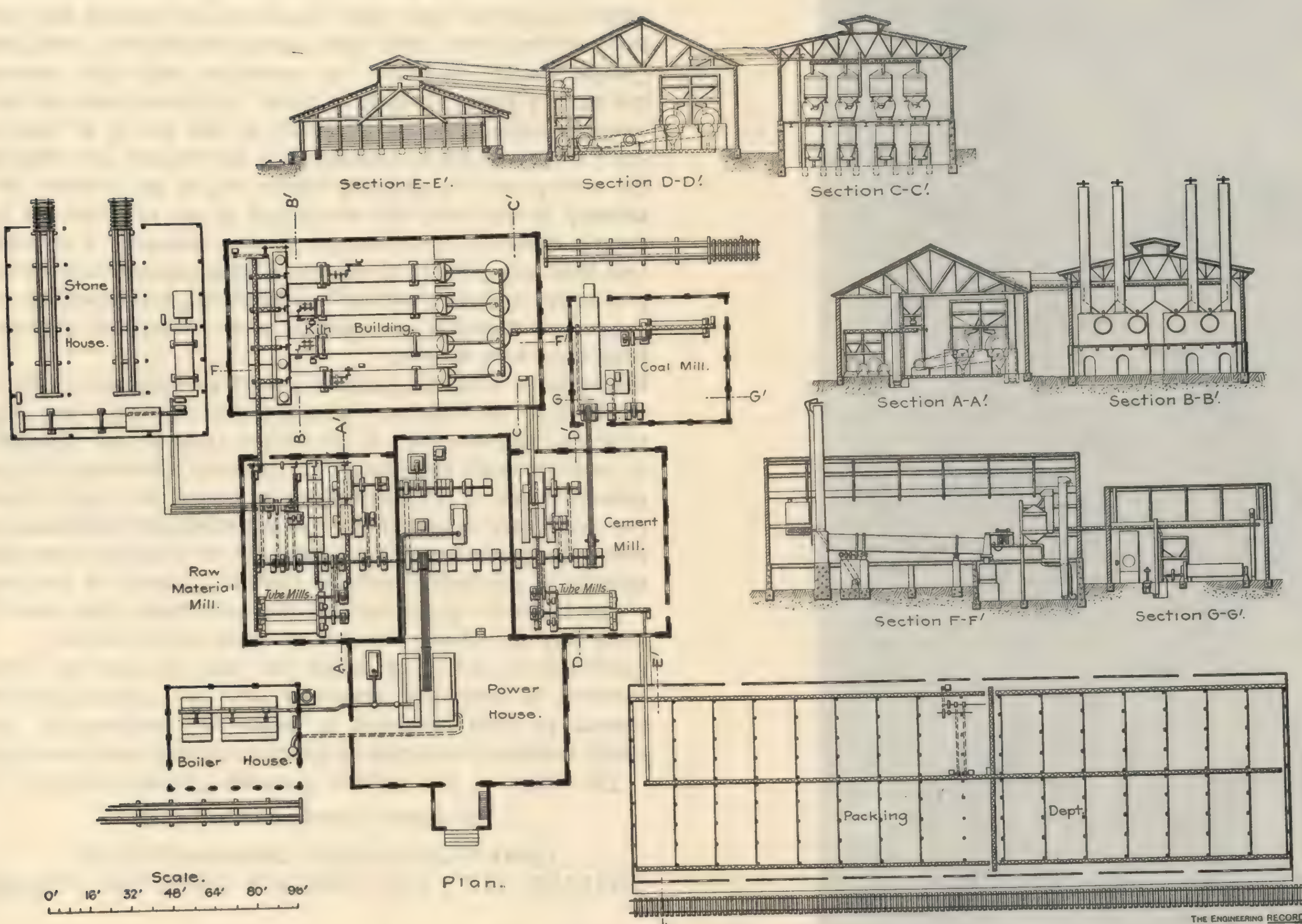

Figure 78.—Plan and Sections of the Buildings, Virginia Portland Cement Company, Craigsville, Va.

Back of
Foldout
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definitely a Portland cement of the highest quality. From the report of this investigation the writer is accorded the privilege of quoting regarding the analyses and tests as follows:

Limestone.	Per cent.	Clay.	Per cent.
Lime	54.3	Silica	53.63
Volatile matter	43.63	Alumina	24.47
Insoluble	1.46	Lime	5.94
Magnesia	0.66	Magnesia	1.79
		Volatile matter	10.03

The above is a typical analysis from the average of many samples, the deviation from this in all cases being very slight, and the following a report of tests of the same material:

Fineness.—Passing No. 50 sieve, 100 per cent.; passing No. 74 sieve, 100 per cent.; passing No. 100 sieve, 100 per cent.; passing No. 200 sieve, 92 per cent.

Setting Time of Neat Cement.—Initial set, 1 hour; final set, 3 hours; percentage of water, 25. Temperature of air, 70 degrees Fahrenheit. Temperature of water, 65 degrees Fahrenheit.

Constancy of Volume Tests.—Normal pat tests, Am. Soc. C. E.: Air pats, good. Cold water pats, good. Accelerated tests: Hot air test, good, hard and sound. Warm water test (Faija), good, hard and sound. Boiling water test (Michaelis), good, hard and sound.

Tensile tests of standard briquettes (1 sq. in. section). Hardening period, one day in air and six in water. Cement seasoned 1 week after calcination.

Proportions of mortar.			Strength
Cement.	Sand.	Water.	in lbs.
1	0	24 per cent.	590
1	0	24 per cent	635
1	0	24 per cent.	590
1	0	24 per cent.	645
1	0	24 per cent.	690
Average			630
1	3	12 per cent.	298
1	3	12 per cent.	342
1	3	12 per cent.	320
1	3	12 per cent.	332
1	3	12 per cent.	332
Average			325

The analyses and tests of the cement as manufactured have shown results as follows:

	Per cent.		Per cent.
Silica	21.20	Lime	63.14
Alumina	7.90	Magnesia	2.40
Oxide of iron	2.82	Sulphuric acid	1.37

Fineness: 96 per cent. passes No. 100 sieve; 72 per cent. passes No. 200 sieve.

Figure 79.—General View of Plant.

Strength.

7 day neat.	7 day sand.	28 day neat.	28 day sand.
635	225	790	385
670	225	715	305
690	260	810	368
633	240	775	358
680	232	807	360
Av. 662	Av. 236	Av. 780	Av. 335

The several buildings comprising the plant with their dimensions are as follows:

1. Power house, 56 x 82 feet, with an extension between mills, 43 x 78 feet; 2, Boiler house, 40 x 50 feet; 3, Stone house, 73 x 80 feet; 4, Raw material mill, 60 x 72 feet; 5, Kiln building, 66 x 119 feet; 6, Cement mill, 60 x 72 feet; 7, Stock house, 75 x 250 feet; Cooper shop, 30 x 60 feet; 8, Coal mill, 48 x 60 feet; Machine shop, 30 x 60 feet.

These have been planned with a view to future extensions, the proposed scheme of which is indicated by the dotted lines in Figure 77. The buildings will be described with their general

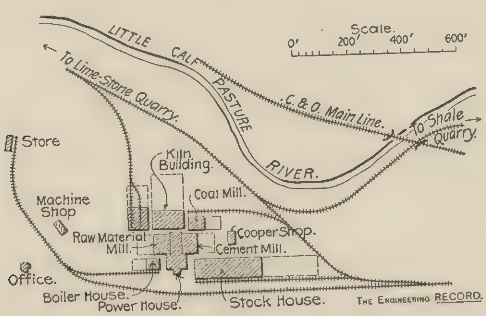


Figure 77.—Arrangement of Buildings.

features in the above order and an endeavor has been made to follow the course of the material from the raw state in the quarries to the finished product in the stock house, so that the continuance of the process may be understood. Figure 78 is a general plan and sections of the works, showing the machinery layout in the various buildings.

Power House.—This consists of a main room, containing the main engine and large compressor and an extension separating the mills, containing an auxiliary engine, generators and small air compressor. The main power installation consists of a **725** horse-power cross-compound, non-condensing engine of the Ham-

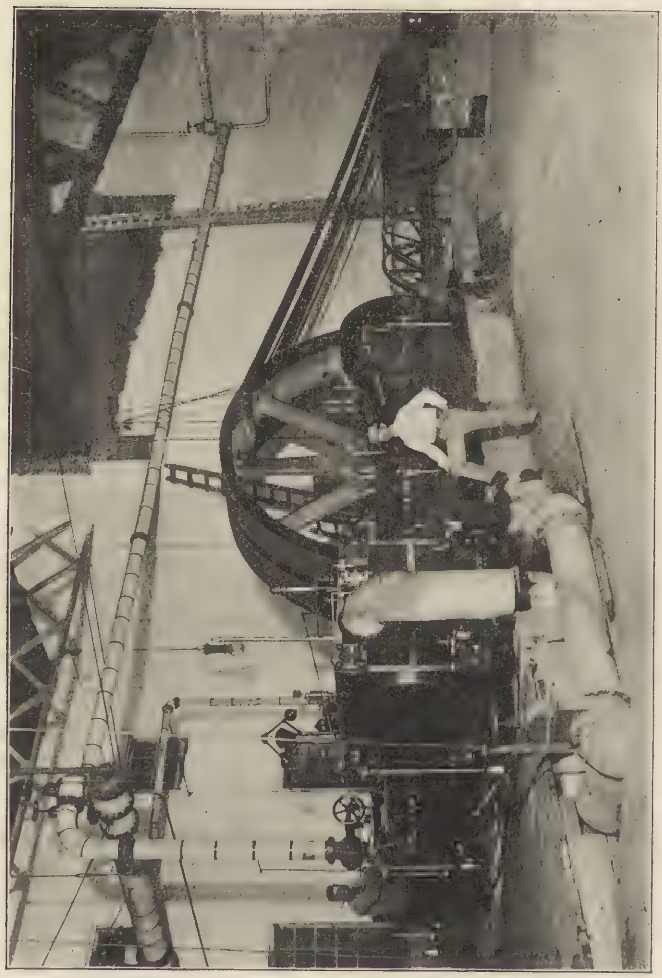


Figure 80.—Main Engine Room.

ilton-Corliss type, made by the Hooven, Owens & Rentschler Company, of Hamilton, O. This is connected by a rope drive to the main line shaft, which drives the machinery of both mills by direct belts, and that of the coal mills by a cross rope drive, shown in Figure 81. The driving belt of each mill has its own friction clutch on the line pulley and any mill can be cut out by releasing the clutch.

A countershaft in the power-house extension is driven from the main shaft by means of a belt, and, when the main engine is out of service, by means of a 250-horse-power high-speed engine made by the Ames Iron Works, of Oswego, N. Y. This shaft drives two direct-current Westinghouse generators, which furnish the power for operating the stone house, kiln building, stock-house and the electric lighting in the various buildings and about the grounds. A small Ingersoll-Sergeant air compressor for supplying air to the coal feed is also driven from this countershaft. This arrangement of power distribution enables the above building to be operated independently of the main power and mills, which is desirable at times.

A steam-driven Ingersoll-Sergeant air compressor is also installed in the main power house for furnishing power for the drills at the limestone quarry.

The boiler plant consists of three 230-horse-power water-tube boilers, one single and two in battery, of the Stirling type, made by the Stirling Company, of Chicago, Ill. Two duplex Smith-Vaile pumps will also be seen located in the boiler house, which supply water by a 6-inch suction line from a mountain stream to a large tank in the tower of the power house from which the boilers, fire line and other uses about the buildings are fed. The exhaust steam from the main engine and large compressor is utilized in a feed-water heater. Coal for the boilers is brought to the building on a trestle, which serves as a storage reserve and from which the coal is fed by a chute direct from the cars to the floor of the boiler house.

Stone House.—The stone house is provided with a double-track trestle connecting directly with the main siding to the quarries. The trestles serve as a storage for the limestone and shale. The limestone is crushed at the quarry in a No. 5 Gates crusher and from the storage deposit is fed directly into an elevator, which deposits it into a revolving rock dryer, furnished by the Ruggles-

Coles Engineering Company. The heat for the drying is obtained from a furnace constituting the end housing of the dryer. After being dried the limestone passes directly to an elevator, which delivers it on an inclined belt conveyor from which it passes to another belt conveyor at right angles, delivering it to large bins over two Krupp ball mills in the raw material mill.

The shale is handled and dried in a manner similar to the limestone. A short screw conveyor brings it from the dryer to an elevator which delivers it to belt conveyors, similar to those de-

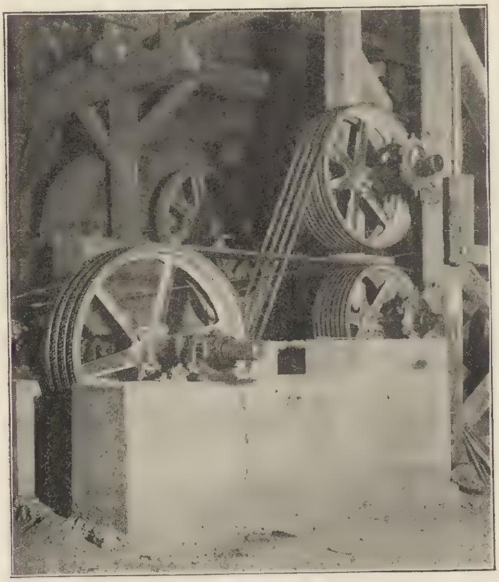


Figure 81.—Drive of Coal Mill.

scribed for handling the dried limestone. These conveyors are carried with the limestone conveyors on a bridge between the stone house and raw-material mill and deposit the shale into a bin over a Buchanan roll crusher, furnished by the Geo. V. Cresson Company, of Philadelphia, Pa. Power for the stone machinery is furnished by a 30-horse-power Westinghouse motor.

Raw Material Mill.—In this mill the raw materials receive their first grinding and mixing. The limestone passing through a battery of two Krupp ball mills is conveyed to an elevator, which raises it to a bin placed over an automatic weighing ma-

chine, made by the New England Automatic Weighing Machine Company. The shale passing through the Buchanan rolls is elevated and conveyed to a set of two rock emery mills, made by the Sturtevant Mill Company, of Boston, Mass., and thence to a set of five sampling bins. From these bins it passes directly by chutes, provided with valves for taking samples, to an underground conveyor, and is conveyed to an elevator, which deposits it in a bin also over the automatic weighing machine and alongside the limestone bin.

We have seen that thus far the method of handling the limestone and shale has been entirely distinct and independent. During the process thus far and just before reaching the automatic scales, the necessary analyses and computation for proportioning the mixtures are made. The proper mixture to give the desired composition is then made by weight in the scales and passes from these by a conveyor to bins over a set of two grit mills, furnished by Thos. Prosser & Son, of New York. The product of these mills is then conveyed and elevated to a large steel tank just back of the kilns and is then ready to be burned.

Kiln Building.—This building is practically two stories high, the kilns being carried on concrete foundations some 10 feet above the general elevation of the other buildings. There are four kilns 60 feet long and 6 feet in diameter, made by Geo. W. Ervien & Company, of Philadelphia, and are turned and mounted in the usual manner. Each kiln has its independent 10-horse-power motor, which drives the countershaft of a set of train gears ending in the pinion, which engages the rack on the body of the kiln.

The raw material is stored in a large steel tank just back of the kiln housings which is provided with a V-shaped hopper bottom for each kiln. A short screw conveyor feeds the material from this tank to the kilns through water-jacketed tubes. The conveyors are operated from a shaft mounted on the kiln housings, driven by a motor. Each conveyor is provided with a clutch, making the feeds independent.

From the other ends of the kilns, the burned material drops through hoods of the usual design directly into clinker tanks, and is there sprayed by a water jet. Below these tanks, cooling grates receive the clinker, which is drawn out or dumped upon the clinker-pit floor. At this point, the clinker is weighed and

elevated and conveyed to bins over a set of Krupp ball mills in the cement mill.

Pulverized coal is used for fuel in the kilns and is received from the coal mill by conveyors which deposit it in the steel cylindrical coal tanks behind each kiln. The bottom of these tanks is provided with a cast-iron semi-circular part, from which a short screw conveyor delivers the coal to a blast pipe leading into the end of the kiln and provided with a patent burner. A low-pressure blast furnished by two Sturtevant blowers carries the coal from the tanks through a pipe to the burners where it is met by the high-pressure blast. The coal feeding and burning device was designed and patented by Mr. Lewis.

Coal Mill.—The coal to be pulverized for the kilns is brought to the coal mill on a trestle which, as in the case of the boiler house track, serves as a storage. The coal is shoveled from the storage or fed by direct chutes from the cars into an elevator which delivers it to a Cummer dryer, furnished by the F. D. Cummer & Son Company, of Cleveland, O. From the dryer it passes directly into a crusher made by Thos. F. Mosser & Son, Allentown, Pa., and from this is elevated and conveyed to a tube mill where it is finally pulverized. From this mill it is elevated and conveyed to the steel storage tanks in the kiln building.

Cement Mill.—In this mill the clinker is ground to the state of finished cement by a set of two Krupp ball mills and two tube mills, from which it is conveyed and elevated to a belt conveyor carrying it to the stock house.

Stock House.—The finished product from the cement mill is received by a long screw conveyor which distributes it into a series of bins for storage. The cement to be packed is brought by a conveyor on either side of the building to the packers department, where it is deposited into a distributing bin, below which the bag and barrel packers are situated. The packing department occupies the center section of the building. The cooperage department occupies a separate building adjacent to the stock house.

Machine Shop.—This shop is well equipped with the best modern machinery, and its equipment consists of a 28-inch back-geared lathe, a 12-inch engine lathe, 24-inch back-geared shaper, 24-inch power drill, power hack saw, and emery wheels. The blacksmith's shop occupies part of the machine shop.

All the buildings thus described are substantial in construction and represent a factory above the average in the Portland cement manufacture. The power house, boiler house, coal mill, raw-material and cement mills are of substantial brick construction with heavy timber trusses and slate roofs. The wooden truss construction was made necessary on account of the crowded condition of the iron market and the impossibility of obtaining ironwork within any reasonable period at the time the plant was designed. The kiln building is constructed of steel columns with brick walls between. The steel trusses are carried on a concrete wall 12 feet high, with large arches between pilasters. These arches, together with an open floor under the kilns, form an ideal means of ventilation. The stone house, cooper shop and machine shop are of frame construction, and the stock house is a frame structure roofed and covered on the sides with slate.

In connection with the establishment of this industry, the company has built an office, commissary department, houses for the general manager and other resident officers of the company, together with a number of houses for the mechanics and workmen. Thus the project makes a complete enterprise and village within its own scope. The buildings of the plant, office, commissary and residences were erected and brought to a satisfactory completion by A. F. Withrow & Company, of Charleston, W. Va.

The officers of the company comprise Mr. W. R. Warren, president; Mr. W. Burnham, vice-president; Mr. Wm. Bradbury, secretary; Mr. F. W. White, treasurer, with headquarters and main office at 81 Fulton street, New York. The resident staff comprises Mr. F. H. Lewis, superintendent; Mr. Watson Vredenburgh, Jr., assistant superintendent; Mr. F. D. Wood, mechanical engineer, and Mr. H. H. Shock, chemist.

The writer was associated with Mr. F. H. Lewis, as assistant engineer on the design and construction of the plant, and was himself assisted by Mr. F. D. Wood, to whom he is indebted for the sketches accompanying this article.

CHAPTER XIV.—THE WHITEHALL PORTLAND CEMENT WORKS, CEMENTON, PA.

By Henry C. Meyer, Jr.

One of the largest single cement mills in the Lehigh Valley is that of the Whitehall Portland Cement Company, at Cementon, about 10 miles west of Allentown, Pa. One-half of the mill, which will have a total of 20 rotary kilns, has been in operation a short time, while the remaining half is rapidly approaching completion. The plant is interesting partly on account of its size, being the largest perhaps of any completed this season, and on account of the fact that electricity is used to drive the major portion of the plant. It is believed to be unusually well arranged for the economical manufacture of cement.

The company possesses some 66 acres of property, situated on the north bank of the Lehigh River and separated from it by the tracks of the Lehigh Valley Railroad. Across the river is the Central Railroad of New Jersey, connecting with the Lehigh Valley Railroad, so that the shipping facilities of both railroads are to be had. The property contains a supply of cement rock that will last many years, while limestone, which is mixed with the cement rock to secure the proper composition in the material, is secured from a neighboring quarry. The mill site is about 1,200 feet from the river and is situated at the bottom of a hill on the side of which, some 300 feet from the mill, the quarry has been opened. A viaduct leads from the quarry to the mill, so that cars containing the cement rock may be run over that portion of mill where rock is crushed. The quarry railroad is of a narrow-gauge shuttle type made by the John A. Mead Company, 3 Broadway, New York. The track runs from the quarry to a shed over large receiving hoppers over the rock crushers. The track is single except for a distance of 50 feet half-way between the quarry and the crusher building. There are two cars fastened by a clutch to an endless cable running in sheaves between the rails. One car is clamped to one cable and the other car to

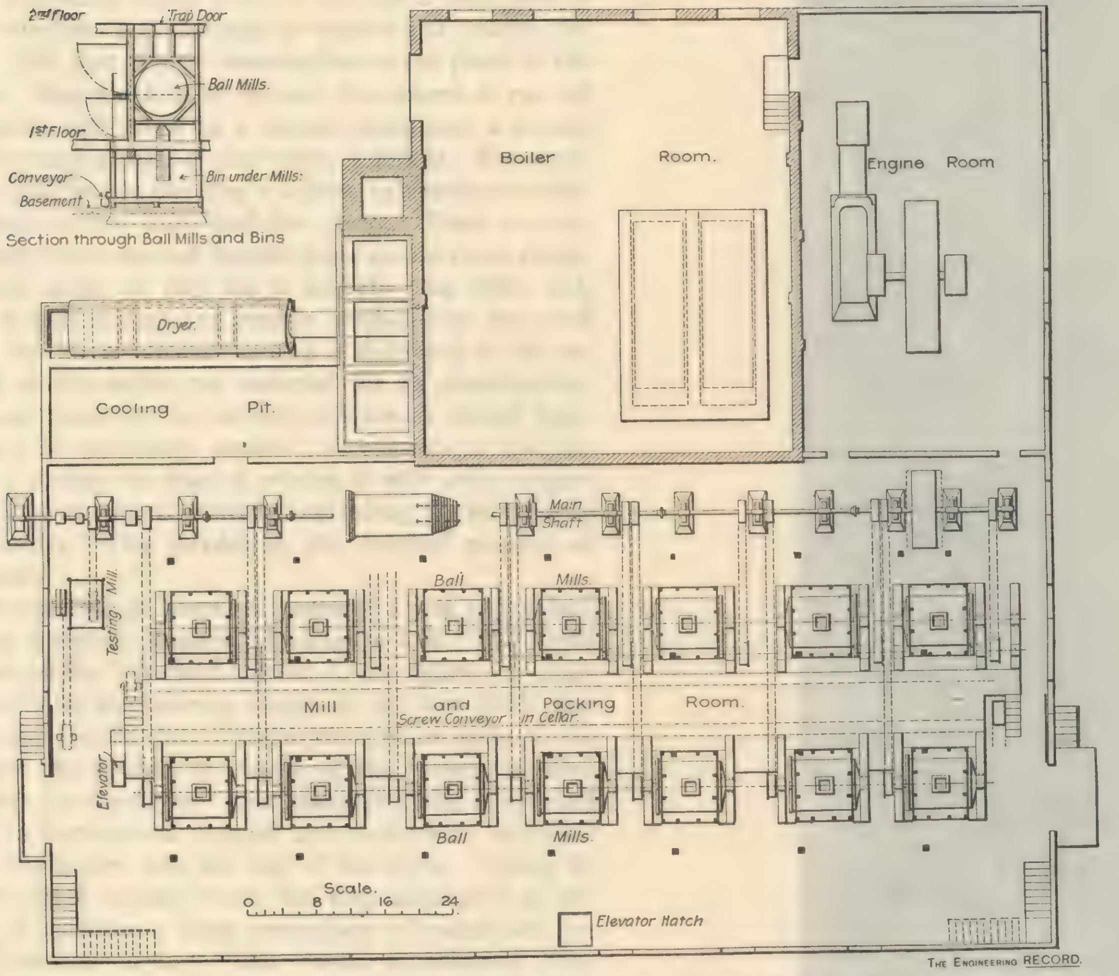


Figure 112.—Plan of the Maryland Cement Company's Works.

Back of
Foldout
Not Imaged

the other cable, so that as one car is moved in one direction the other car will go in the opposite direction. The cars pass each other where the double track is laid, and each car takes the proper track due to the fact that the flanges on the wheel of one car are on the inside of the rails while on the other car they are on the outside and the switches are arranged for this.

Figure 82.—View of the Whitehall Portland Cement Works.

The cars are of steel and each has a capacity of 3 cubic yards. They are dumped by a level releasing the sides which are hinged at the top. There are six cars, so that four may be filled in the quarry, while the others are carrying rock. The cable is drawn by a 25-horse-power electric motor operated with a controller at the east end of the crusher building. By running the motor forward or backward either car is run to or from the quarry. One man can operate the cars and dump them at the crusher building. The Rawson & Morrison Manufacturing Company, New York City, installed the railroad described. The quarry is worked by three air drills supplied by an Ingersoll-Sergeant air compressor located in the auxiliary power house.

Figure 85.—View in Raw-Stone Grinding Building.

The cars deliver the rock into McCully crushers, of which there are four. The bases of the crushers rest upon heavy concrete piers carried up to a height of 29 feet above ground level. This high elevation of the crushers makes it possible for them to discharge their product by gravity into the raw-material stock bins, which are of brick construction, extending along the rear end of the dryer building, as shown in the plan, Figure 83, and in the reproduction of a photograph, Figure 85. Each crusher may deliver into either of a pair of bins, one, the larger of the two, being for crushed cement rock and the other for crushed limestone. Material from each bin is shoveled upon wheel-barrows, weighed out in the proportion that the analysis shows to be proper, and dumped in the hopper of an elevator discharging the mixture into rotary dryers. There are six of these arranged in pairs and each pair is driven by an electric motor.

The dried material falls from the lower end of the dryer upon a belt conveyor lying at an angle of about 30 degrees from the horizontal and this conveys the material into an elevator depositing it in Krupp ball and tube mills, six in all, one to each dryer. From the three ball and tube mills on the left the ground raw materials pass by means of the elevator and conveyor shown, to the kiln building on the left, while those from the ball and tube mills on the right pass to the kiln buildings on the right, the kiln buildings and finishing mills being separated by the engine and boiler rooms as shown.

As will be seen from the elevation in Figure 84, the kilns are elevated considerably above the floors of the raw material and finishing mills, and clinker pits are constructed under the discharging ends of the kilns. The clinker is shoveled into an elevator boot delivering the clinker to Krupp ball mills from which it is passed through tube mills, as was done before it was burned to clinker. It is rather interesting to note that manual labor is depended on to supply materials to the dryers and to furnish clinker to the ball mills in the finishing mill instead of machinery, as used in some of the most recent plants. In justification of this arrangement Mr. Cederberg, the designer of the plant, stated that he believed some mills depend too much on machinery and that he thought it advisable to handle his product at the two points mentioned by manual labor, for if a man gave out another could take his place, whereas the break-down

Figure 86.—View of Kiln-Driving Machinery.

of machinery might necessitate a shut-down of the entire plant —a serious matter when it is remembered that the shut-down of a plant turning out 2,500 barrels a day for 12 hours means a loss of nearly $2,000, enough to pay the wages of several men for a long period. The finishing mill is almost a duplicate of the raw-material mill. The grinding machinery was furnished by Thomas Prosser & Son, of New York City, while the kilns, dryers and main engines were supplied by the Vulcan Iron Works, of Wilkesbarre, Pa.

Electric power, which is used almost entirely for driving the works, is usually generated in the engine and dynamo room between the kiln buildings; but there is a relay engine driving two 350-kilowatt electric generators in a separate building. The latter is a single-cylinder non-condensing Green, of 900 horse-power, built by the Providence Engineering Works. The main engine room contains two cross-compound condensing or non-condensing Corliss engines, each of 700 horse-power. The cylinders of these engines are 22 and 36 inches in diameter and 42 inches stroke, and the revolutions are 75 per minute. Each engine is belted to a jack shaft to which two 250-kilowatt generators are connected by compression couplings. The two jack shafts can be disconnected within 3 minutes' time. The engine-room floor is a considerable distance above the Lehigh River, so a pit, 26 feet deep, with heavy concrete walls, was constructed; in this the condensers, each consisting of a 10 x 12-inch Dean pump attached to a jet condenser, are located. The elevation of the pit is such that the maximum lift on the condensers at low water in the river is 18 feet. The air pump suction and discharge run in a tunnel, 1,280 feet long, 6 feet high and 3 feet wide, with concrete walls, bottom and roof. Its size, it will be noticed, is ample to allow inspection of the pipes, also repairs, the latter being important in case an air leak should occur in the suction pipe.

The electric equipment consists of four 250-kilowatt generators in the main power house running at 540 revolutions per minute and generating direct-current at 250 volts. The auxiliary power house contains two 350-kilowatt generators running at 500 revolutions per minute. There are a total of 13 motors about the plant. There are 7 motors of 250 horse-power each in the raw-material and finishing mills, each motor driving two ball

Figure 87.—View of one of the Main Engines.

mills and two tube mills, or two batteries of ball and tube mills. These motors are mounted upon heavy concrete foundations and are belted to a line shaft in the mills, as shown in Figure 85. All of the machinery in the mill is driven by a belt from this shaft. Each kiln building is driven by a 250-horse-power motor located in the engine room as shown. As the floor of the kiln building is some distance above that of the engine room, the shaft driving the kilns is carried through the engine room wall to a pillow block mounted upon a high concrete pier. This same shaft drives the coal mill adjacent to the kiln buildings. It is expected that the cost per barrel of cement will be very low on account of the little help required to run the machinery. All motors are to be usually controlled from the engine room, but any motor can be stopped from its respective department by means of a switch. The electrical apparatus was made by the Keystone Electric Company, and the shafting and pulleys by the George V. Cresson Company, of Philadelphia, and the Hill Clutch Company, of Cleveland, O.

The electric lighting plant comprises some 1,200 incandescent and 30 arc lights, the latter being scattered about the buildings, grounds and quarry. Electricity for lights is generated in a separate building by means of three Sprague dynamos, each of 30 kilowatts capacity, generating current at 120 volts. Each dynamo is driven by a Westinghouse Standard Junior engine.

The boiler room contains eight Stirling water-tube boilers, a total of 2,000 horse-power. Each has its independent stack 65 feet high and 42 inches in diameter. The boilers are connected to a main steam pipe line by bent pipes. The main rests upon roller bearings to permit it to expand freely. The pipe supplying steam to the engines is of generous size and all branches from it are connected to the top so that the condensation in the main cannot reach the engine cylinder.

Coal pockets capable of storing 2,000 tons are located outside of the boiler room, coal cars being run over them so that they can dump into the bunkers. In line with the bunkers, outside the kiln buildings and also beneath the railroad track, are bunkers for bituminous coal used in burning clinker in the rotary kilns. There are two coal mills, one at the outer end of each kiln building, as shown in the plan. Coal is conveyed to each mill and elevated into rotary dryers, of which there are one to each tube

mill, being ground to a fine powder in the latter. It is then elevated and conveyed to coal-storage bins opposite the end of the kilns to which it is fed by a coal-burning apparatus made by the B. F. Sturtevant Company, and described in detail in The Engineering Record of December 16, 1899. (See Chapter IX.) The speed of the conveyor feeding coal to each kiln and the kiln speed is controlled by a speed regulator made by the Reeves Pulley Company, of Columbus, Ind.

As the finished cement comes from the tube mills it is elevated and conveyed to the stock house, which is an iron and brick structure, 400 feet long and 80 feet wide, with a five-story center occupied by a machine shop in the basement and a cooper shop and barrel storage on the floors above. Each end of the stock house is occupied by 10 bins 53 feet deep, 14 feet wide and 24 feet high. In these the cement is stored and it is supplied by a drag conveyor running over the top of the bins. Opposite alternate partition walls barrel packers are located. Cement is shoveled into an elevator lifting the cement to the packers. Railroad tracks extend along the front of the stock house and there is another track for car storage.

The buildings are of steel and brick, and are practically fireproof. Four million bricks, 27,000 cubic yards of concrete and 1,000 tons of structural iron work were used in the construction of the plant. It was designed by Mr. A. H. Cederberg, the engineer, and until recently, its superintendent. Mr. Cederberg was assisted in his work by Messrs. W. O. Dunseeth and H. D. Osgood as draftsmen and W. B. Thorn as head bookkeeper. The officers of the company are: Dr. J. S. Wentz, president; Mr. Oliver Williams, vice-president; Mr. A. C. Leisuring, chairman executive committee; J. M. Ritcher, secretary; W. B. Whitney, treasurer; W. C. Kent, assistant treasurer, and Messrs. M. S. Kemmerer, E. H. Jones and J. W. Fuller, directors. The Engineering Record is indebted to Mr. Cederberg and to the Vulcan Iron Works for photographs from which some of the illustrations were prepared.

CHAPTER XV.—THE PLANT OF THE LAWRENCE CEMENT COMPANY, BINNEWATER, N. Y.

The Manufacture of Hoffman Rosendale Cement.

By Frederick H. Lewis, M. Am. Soc. C. E.

The Rosendale cements of New York are manufactured from a deposit of natural cement rock known as the Tentaculate or water lime deposit of the Lower Helderberg group of the New York Geological Survey. This corresponds to Formation No. 6 of the Pennsylvania series, and is consequently a different and later formation from the Silurian limestone (No. 2) employed for cement making in Pennsylvania. There are at the present time 15 different firms or companies making cement from this deposit in Ulster County, New York. Within a radius of five miles around the village of Rosendale are grouped numerous plants producing the bulk of the output. The village is situated on Rondout Creek, and the Delaware and Hudson Canal and Walkill Valley Railways pass through it. Nearer Kingston, there is another group of works along Rondout Creek, and on the west shore of the Hudson River. The largest output in the district is that of the Lawrence Cement Company, operating three plants, which in recent years have produced rather more than a million barrels of cement annually. It is the works of this company which the writer now has the opportunity to illustrate and describe, through the courtesy of Messrs. E. R. Ackerman and Henry McMurtry, president and general superintendent, respectively, of the Lawrence Cement Company.

Before giving details of the plant, however, a brief general description will serve to place the reader in touch with the Rosendale industry as a whole, and to define its relation to the American production of hydraulic cements. The Rosendale cement industry is at once the oldest and the most conservative manufacture of hydraulic cement in this country. Dating from 1832, it was developed and established in early days by practical methods of trial and error, and has held to the things which experience has approved, changing little from year to

year. In 40 years plant and methods have undergone no essential changes. And, following such lines, the industry has been at once consistent and successful. In this limited district, in recent years, the annual output has been between three and three and a half million barrels of cement, selling for about $2,000,000 at the works. These figures represent from 40 to 45 per cent. in quantity and 50 per cent. in value of the total natural rock cement production of the United States. Since 1847 the value of cement produced is estimated to be $70,000,000. In relative importance it has been the most valuable cement-producing district in America, and still is so, though at the present time the newer Portland industry of Eastern Pennsylvania is a close second.

The rock deposit is a magnesian limestone, of which two different beds, known respectively as the "light rock" and the "dark rock," are quarried for cement. Separating these two beds is a middle series of strata varying from 8 to 20 feet in thickness which is not used. In Gen. Gillmore's investigations of these Rosendale rocks, 17 different layers or strata are reported to occur in a thickness of some 46 feet, which comprises the entire water-lime deposit. It is said that these 17 strata can be everywhere distinguished in the outcrop in Ulster County, though the character of the strata varies considerably in different places. Four strata are in the upper or light rock series, three in the unused middle series and 10 in the lower or dark rock.

Gen. Gillmore describes the deposit in the following terms: "The beds are found occupying every conceivable inclination to the horizon, being sometimes vertical, seldom on a level, and ordinarily dipping at a greater or less degree either to the northwest or to the southeast. The entire face of the country in this region exhibits unmistakable evidence of having been subjected to a succession of remarkable upheavings;" "by which the strata in many localities were twisted into a variety of complex and tortuous shapes. The useful effect of these upheavings has been to develop into accessible and convenient positions a vast amount of cement stone that would otherwise have been buried beyond the practicable reach of ordinary skill. The whole deposit is subdivided into several distinct layers, which are widely dissimilar, as a general thing, in the color, grain and texture of the raw stone, and also in their hydraulic properties after cal-

cination. No one manufacturer makes use of all of these beds, and no two of them of the same beds in the same proportions."

In its appearance the cement may be recognized by its dark color, which is characteristic of Rosendale cements, with the exception, it is said, of those made at High Falls. In chemical composition the cements are remarkable for the high proportion of magnesia they contain. Abroad there are few magnesian cements, and, while most of the natural cements of this country contain magnesia, the proportion is generally small in comparison with the lime. The amount of magnesia varies considerably in different Rosendale brands, but the following analysis made for the writer in a Philadelphia laboratory may serve as typical of the cements as a class:

	Per cent.		Per cent.
Silica	24.30	Lime	33.70
Alumina	7.22	Magnesia	20.94
Ferric oxide	5.06	Volatile matter and undetermined	8.78

With respect to magnesia in natural cements it may be interesting to note here the conditions of its successful use in these Rosendale cements. Calcined magnesia has decided hydraulic properties, hardening in water to a stone-like mass. Magnesia also combines, as lime does with silica and alumina in cement, to form crystalline silicates and aluminates, which are said to be quite equal in hardness to similar lime compounds. But this ready hydration and combination of the magnesia only takes place when the rock is lightly burnt. When hard burnt, the magnesia becomes sluggish and hydrates with extreme slowness. The condition, then, of its successful use is light burning, and this is the precaution everywhere observed in the Rosendale factories. All the hard-burnt clinkered lumps are carefully picked out and discarded as waste product. Made in this way the Rosendale cements have been successfully employed through a long term of years in many important structures.

At the present time the Lawrence Cement Company operates three different plants. The first of these is at Eddyville, just at the head of tidewater, on Rondout Creek, and but a mile or so outside of Kingston. Here there is a large mill, with crushing and grinding machinery; a cooper shop to correspond, and warehouses and shipping wharves for forwarding

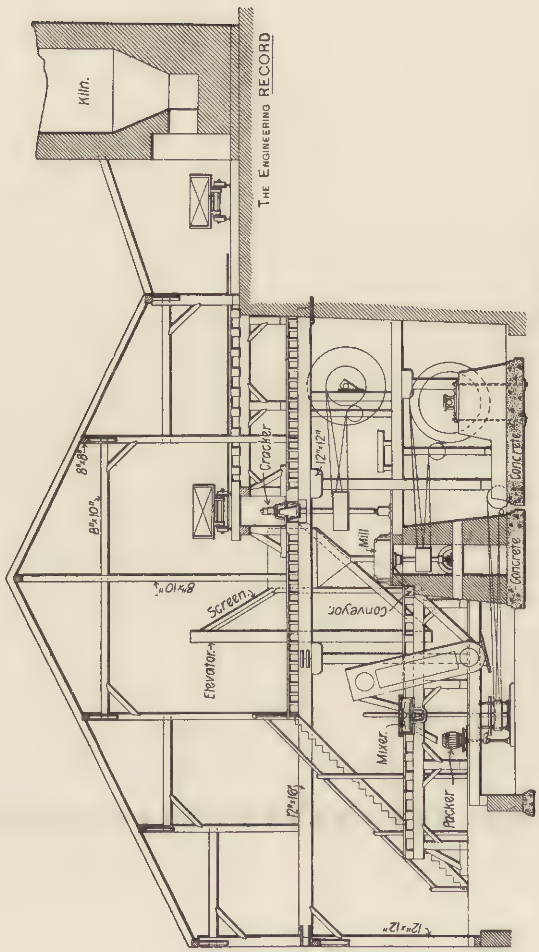


Figure 89.—Cross-Section Through Mill.

cement by the Hudson River. The second plant is at Hickory Bush, three miles or so from Eddyville, and back some distance from the Creek Valley. At Hickory Bush there are several quarries or mines for cement rock, 36 continuous kilns, storehouses for winter product, and repair shops for cars and machinery. Between Eddyville and Hickory Bush there is a tramway operated jointly by the Lawrence Company and another firm. By this tramway the cement which is calcined at Hickory Bush is carried to the plant at Eddyville to be ground, packed and shipped; the two plants being thus mutually interdependent. As Hickory Bush is in the hills, the grade of the tramway is descending toward Eddyville, and large loads can be carried in the direction of the traffic.

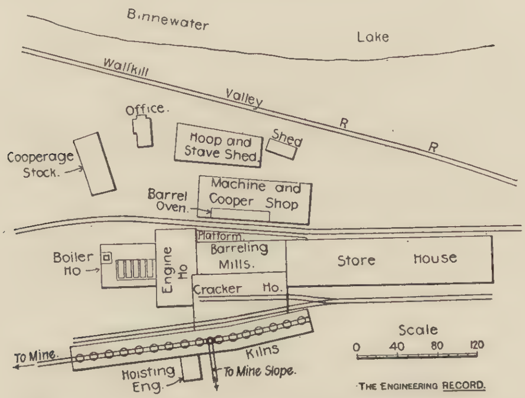


Figure 88.—Plan of the Binnewater Works.

The third plant is at Binnewater, some two miles beyond Hickory Bush. This is a complete plant in itself, operated independently of the other two. The Walkill Valley Railroad runs directly through the property and is the shipping outlet for the works. As the Binnewater plant is complete, and in its details quite similar to the others, it has been selected as representative of the plant and methods of the company.

The general plan of the Binnewater works is shown in Figure 88. To appreciate its appearance, however, and the advantages of its arrangement, it should be noted in examining the plan that it is a hillside plant. That is, the kilns are built directly against the side of a high hill in which the rock is

Figure 90.—View of the Works at Binnewater.

mined, and in such a position that their tops are close to and a little below the outcrop of the cement rock, and consequently a little below the head of the mine slope. This greatly simplifies the work at the kiln tops. From the top to the bottom of the kilns is 30 feet, and the mill buildings are so set that the third floor is about on a level with the bottom of the kilns. The burnt rock is thus discharged from the kilns most conveniently for handling in the reducing and grinding machinery. The section of the mill, Figure 89, shows the position of the base of the kilns.

The track leading directly back from the kiln tops, as shown in Figure 88, enters the portal of a mine directly in the rear and descends a slope in the dark rock deposit (which here dips at an angle of about 45 degrees) to the working headings below, which are at a considerable depth. The track at the left, Figure 88, leads to a second mine more recently developed, which is some two or three hundred yards distant, and outcrops higher up on the hillside. The site of the works has thus been admirably chosen for the economical handling of the material in manufacture. Figure 90 is a view of the Binnewater works.

At Binnewater the dark rock deposit, which is the lower bed of cement rock, is about 18 feet thick, the light rock from 10 feet to 17 feet, and the unworked strata between the two about 12 feet. The dip varies somewhat, but may be generally called 45 degrees. With such narrow beds of cement rock and a dip of this character an open quarry cannot long be used economically, and at Binnewater the cement rock is now all mined by a series of slopes and headings which remove all the cement rock except the pillars required to support the hanging walls. These pillars are spaced some 40 or 50 feet apart.

The general mining scheme has been to run a slope down some 40 feet deep, following the dip of the dark rock deposit, and then to start breasts or headings in both directions along its strike. The headings will thus have working faces about 40 feet high. The rock, as it falls to the bottom, is loaded on cars, which are run back to the foot of the slope and hauled up by cable. When these headings have been run out to daylight, or to property limits, or far enough for economical working, the slope is then run down 40 or 50 feet further and new headings are started from the lower level. To get at the light

Figure 91.—View of Track in the Slope.

rock deposit, which is overhead, the plan is to cut level gangways into it from the gangways in the dark rock. These gangways cut through the hanging wall into the bed of light rock, and headings are then started in it in both directions, the same as in the lower formation. The connection between the two beds of rock is directly in front of, or adjacent to, a slope, so that all cars coming from working breasts in the light rocks are conveniently handled.

Figure 91 is a photographic view of the track descending the slope of the western mine and gives an excellent idea of the appearance of the excavation. This picture is taken a short distance below the outcrop, which has been worked out to the open air, except for the pillars. The clean line of cleavage between the cement rock and the hanging wall is apparent, and there is a quite similar cleavage in the bottom. The mines are fully equipped with air drills, and for blasting, high explosives are used. The western mine is quite free from water and requires no pumping. The other mine, just back of the kilns, has some water in the headings, though not very much, which it is necessary to pump out.

Reference has been repeatedly made to the "light rock" and "dark rock" deposits, without sufficiently explaining what the distinction is. The terms are perfectly natural, being based not alone on color, but on an equally marked difference in the properties of the two beds of rock. Both rocks are hard, compact and close grained, the light rock having a steely-blue color and the dark a duller and deader color and more shaly appearance. This difference in color persists after calcination, the light rock being yellow and the dark a redder, or dark sienna, color. Apparently the light rock contains the most lime and the dark the most clay. At all events, it is a tradition of the works that no good cement can be made without a mixture of the two, which is very readily made, because of a difference in color which enables them to be distinguished from each other either before or after calcination.

The kilns used are shown in vertical section in Figure 92. In horizontal section they are round, 10 feet in diameter in the body and 28 feet high. They are operated continuously by drawing from the bottom and charging from the top. No work, however, is done on the night turn. The kilns are charged up

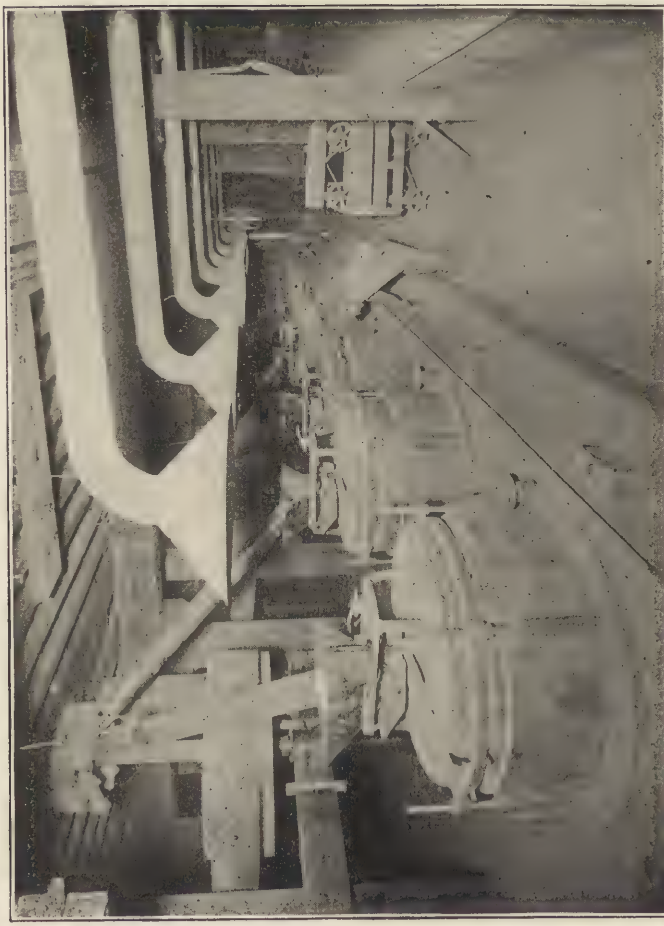


Figure 93.—View of the Mills.

full in the afternoon, and in the morning have burned well up, showing red coals on top. They then require to be well shaken down at the bottom and well charged at the top at the outset of a day's work. In charging, a layer of rock is thrown in, and on it a thin layer of anthracite pea coal, then another layer of rock, etc. As light burning is desirable, the fuel consumption is low, and the output of cement per ton of coal is quite high. Each kiln yields from 90 to 100 barrels of merchantable cement stone per day, after discarding all hard burnt clinker and sorting out the underburnt for recalcination.

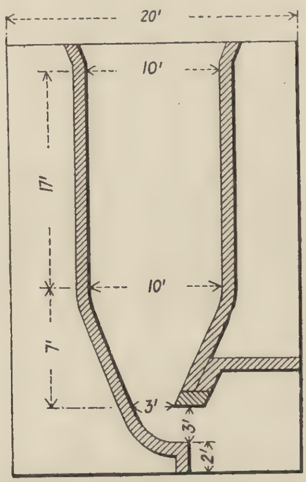


Figure 92.—Section of a Kiln.

This sorting of the product goes on all day at the base of the kilns to keep the mills supplied. It is the rule to grind up each day's product as it is made, carrying over no stock of calcined rock. Figure 89 gives a section of the mill. Cars loaded at the bottom of the kilns are run in and discharged directly over the crackers. These crackers are of the coffee-mill pattern, as shown, and are made of cast iron. The calcined rock is soft and readily crushed, descending forthwith by a chute to a conveyor boot. There are eight crackers and as many conveyors carrying up the cement to a sufficient height to permit it to descend over bolting screens or separators before falling into the hoppers of the mills. Some 25 to 30 per cent. of the cement is found to be sufficiently reduced in the crackers to pass the bolting screens, and this material is carried directly to the barrel packers, relieving the mill stones to that extent. Figure 93 is a view of the mills. Fourteen run of mill stones are employed, the top stones being driven. A grit or quartzite rock, found quite near by on the Shawangunk Mountain, has been employed for mill stones for many years, and answers the purpose very well. The drive and the details of conveyors are clearly shown in Figure 89, and the plan, Figure 88, shows the relative position of the mills, the cooper shop and the storehouse.

No bulk stock of cement is carried at all. All the product is packed as it is ground, and nearly all of it in barrels. The use of bags is not in favor in the Rosendale district. The barrels are paper lined and a barrel of cement weighs 320 pounds gross, with about 20 pounds tare.

There are five return tubular boilers, developing some 1,500 horse-power, for two tandem compound Corliss engines, built by Messrs. C. & G. Cooper & Company, Mt. Vernon, O. These are required to drive the reducing and conveying machinery. The laboratory facilities of the works are only those required to determine the fineness of the cement and its tensile strength in standard briquettes. Every day's product is tested in this way, the standard being, for fineness, 95 per cent. to pass the No. 50 sieve, and for strength, from 70 to 100 pounds, in neat briquettes at the end of 24 hours.

The plant is extremely interesting to visit, as an excellent example of practice in the Rosendale district, and hence fairly representative of an industry which is at once the oldest and the largest cement manufacture we have in America.

CHAPTER XVI.—THE PLANT OF THE NEW YORK & ROSENDALE CEMENT COMPANY, ROSENDALE, N. Y.

By Frederick H. Lewis, M. Am. Soc. C. E.

The first discovery of water-lime rocks in America was made at the village of Rosendale. It was observed that lime made from certain limestone rocks there set and hardened when mixed with water, instead of slaking as ordinary lime does. The date generally accepted for this discovery is 1823 and the site is supposed to have been the same as that now worked by the New York & Rosendale Cement Company at its Rosendale works. This company manufactures two grades of cement, known respectively as the Brooklyn Bridge and Hudson River brands, the former being a little finer ground and a little higher in tensile strength than the latter. It operates two plants, with a total production of cement of both grades of 3,000 barrels per day. One of the plants is at Wilbur, near Kingston, and the other, which is the subject of the present article, is at Rosendale.

The village is located on both sides of Rondout Creek. The Delaware and Hudson Canal runs along the north bank of the creek, and at Rosendale is close to the edge of the mountain-side at the back of the village. Perched between the bluff and the canal is the cement works. The canal is thus the carrier for the company, bringing in coal from Pennsylvania and carrying cement to tidewater, some five or six miles below, or inland by way of Port Jervis. The main quarry or mine of the company lies several hundred yards to the west of the village. The outcrop of rock at this point has been developed in an extremely picturesque manner close alongside the viaduct of the Wallkill Valley Railroad, as is shown in Figure 94, which is reproduced from a photograph taken directly from the deck of the viaduct. There is a compressor plant at this point and a hoisting engine hauling up cars of rock by a cable for a group of five large kilns which appear in the foreground of the figure. The mine at this point has been developed for several hundred feet northward

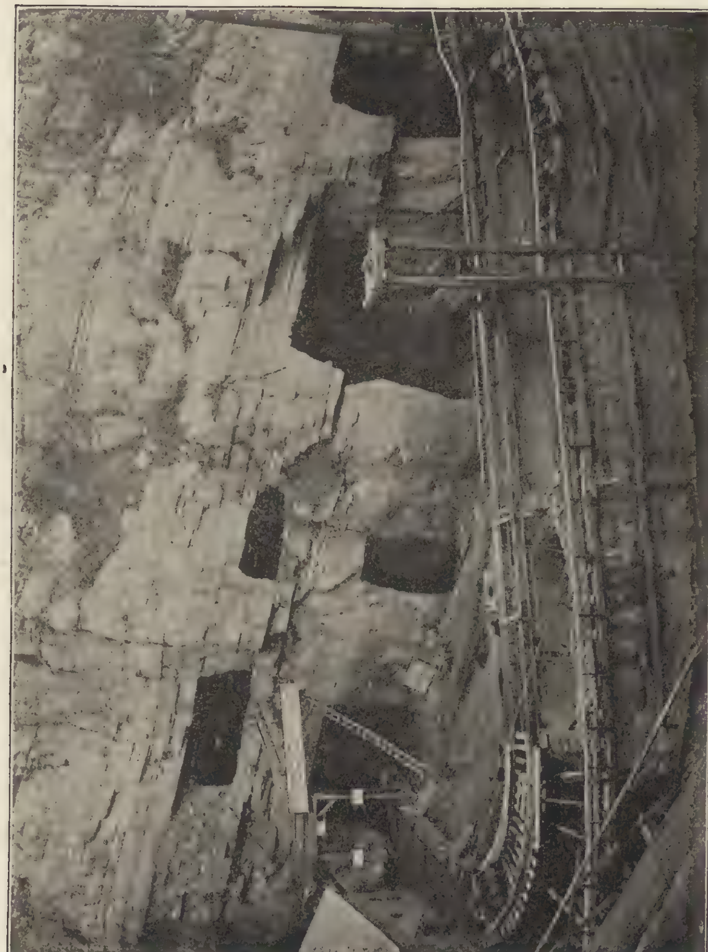


Figure 94.—Entrance to Quarry of the New York & Rosendale Cement Company.

and eastward in the dark rock deposit. Figure 95 shows a view at the foot of the working.

As noted above, there is at the viaduct only a power plant and five kilns. At the village there is a power plant and ten kilns, and the mills, cooper shops, storehouses, etc., required to handle the extra output of the kilns at both places. The village plant is shown in Figure 96. To reach the mine from it a long rock slope tunnel has been driven, passing through the light rock workings and striking the dark rock deposit about at the foot of the present slope. All cement rock for the village plant is drawn from the mine by cable up this rock slope by a hoisting engine installed for this service (Figure 96). Under the same roof there is a second air compressor for drills in the light rock headings.

The dip of the cement rock deposit is only 30 to 40 degrees from the horizontal, and the thickness of the beds are about as follows: Dark rock, 18 feet; intermediate, 10 feet; light rock, 12 feet. The mine has been skilfully developed, and, on account of its accessibility, it is much visited as an object of interest. Air drills and high explosives are employed only in mining. The only hand drilling is for an occasional blockhole in breaking up a boulder. There is practically no water in the dark rock headings, but in the light rock and in the rock slope tunnel there is, and this has to be continually pumped out.

All rock is run out in hopper bottom cars on tracks leading directly over the kiln tops, and is dumped without handling. The company uses nine round kilns of the type generally found in the Rosendale district, and has, besides, six kilns of oval section and much greater capacity. These kilns, as first built, were really rectangular in section, with rounded corners. These were, however, found to choke up at the corners and the fire-clay lining had a tendency to bulge, so the section was made elliptical, with very satisfactory results. Figure 94 shows the tops of large kilns of both sections. They yield 250 barrels of cement per day. At the base the walls of these kilns are drawn in on two sides, to make a wide hopper opening at the bottom on to a broad plate or shelf. The clinker spreads out over the shelf, affording ample room for several men to work discharging calcined rock. There is a wide arch carrying the body of the kiln above this discharging shelf, and under the arch a spur track is run for cars. In the

Figure 95.—View in the Quarry.

case of the smaller round kilns, this arch below is so placed in the wall that two kilns discharge under it, and the arch is thus wide enough for a spur to run in as before. This arrangement of tracks is shown in Figure 96. In this plant the bottom of the kilns is on a level with the ground floor of the mill and it is

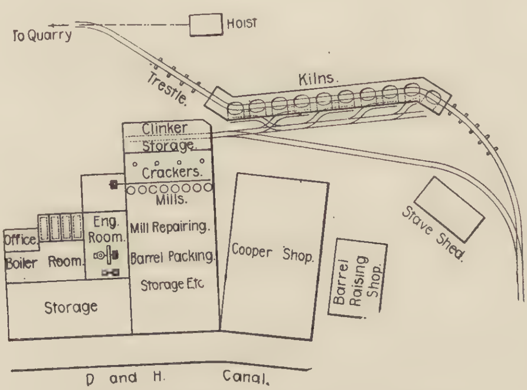


Figure 96.—Plan of the Village Plant.

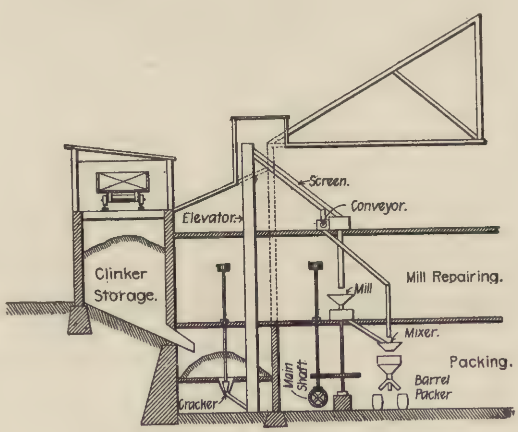


Figure 97.—Section of the Mill.

necessary to draw loaded cars up an incline plane to discharge the clinker into bins above the crushers, as shown in Figure 97.

The section of the mill is shown fully in this Figure 97. The material is passed first through crushers and then is carried up to pass over separating screens. The coarse stuff goes to the

mills and the fine to packing hoppers. The power plant is an old installation of return tubular boilers and a vertical slide-valve engine. The laboratory work is limited to tests for fineness and for tensile strength of neat cement, but the apparatus is excellent and the work very well done.

With the canal directly alongside, shipments are made direct from the stock house to boats alongside. A skeleton tower is built at the water's edge alongside the stock house, and as the barrels run down a plank above the boat they are secured to hooks on the end of a rope passing over a system of blocks in the tower above. A man stationed above drops the barrel easily with a little tension on the slack end of the rope, and a counterweight quickly draws the rope back when the barrel is relieved below. The loading is done in this way very simply and with great rapidity.

CHAPTER XVII.—THE PLANT OF THE MILWAUKEE CEMENT COMPANY, MILWAUKEE, WIS.

By Frederick H. Lewis, M. Am. Soc. C. E.

The Milwaukee Cement Company, manufacturing something over a half million barrels of natural rock cement annually, operates two plants directly alongside the Milwaukee River and something like a mile north of the limits of the city of Milwaukee, Wis. These are known respectively as Mills Nos. 1 and 2. Both plants are thoroughly modern in design and equipment, no

Figure 98.—General View of the Plant.

part of either works being over 10 years old. The company began the manufacture of cement in 1876 at the No. 1 works and rebuilt the plant there complete in 1893. It now has nine continuous kilns with a capacity of 1,200 barrels per day. In 1880 and 1889 the No. 2 plant was built with 20 kilns and a per diem capacity of 2,800 barrels. It is this plant which is now illustrated and described for the readers of The Engineering Record. All things considered, it may be said to more fully illustrate the "state of the art" in manufacturing natural rock cement than any one American plant which could be selected. The writer

is much indebted to Messrs. J. R. Berthelet, manager, and H. Campbell, superintendent, for an opportunity to examine the plant and for drawings and photographs from which the illustrations have been prepared. Figure 98 is a general view of the plant and Figure 99 is a general plan.

In general character, in chemical composition and in geological horizon the water-lime rocks at Milwaukee are quite similar to those in the Rosendale district in Ulster County, N. Y. The products are also quite similar in hydraulic activity and in the strength developed at different periods. How nearly the cements resemble each other will be seen from the following comparison of analyses between the Milwaukee Cement and the Old Newark Rosendale as follows:

	Milwaukee. Per cent.	Old Newark. Per cent.
Silica	25.16	24.42
Alumina	6.33	8.16
Iron oxide	1.71	3.96
Lime	36.08	36.30
Magnesia	18.38	16.93

At Milwaukee the cement rock deposit is 22 feet in thickness and is worked in open quarry over a working face some 800 feet long. There is little stripping required, and as there are 14 dis-

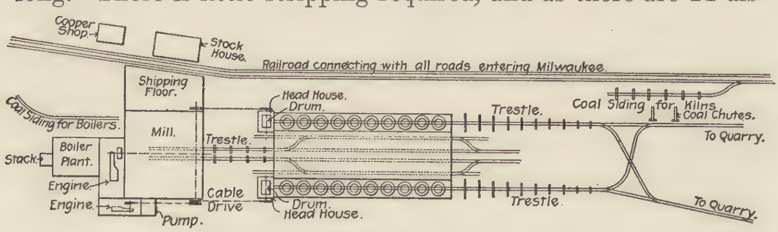


Figure 99.—General Plan of the Plant.

tinct strata in the 22 feet of rock it breaks up very well under explosives. There is but one heavy stratum which requires occasional block holes. Ingersoll-Sergeant steam drills are used and the scheme is to drill a long line of holes vertically on the "bench" of the rock and discharge them simultaneously. This throws into the bottom a long stretch of rock of the full depth of the deposit, and generally well broken up. Operating in this way, one large drill on the bench and a small one in the bottom for block holes and occasional bottom charges will ordinarily do all the drilling for the output of the plant. The blasting is done with dynamite.

The quarry lies low along the river just west of the kilns and is shown in Figure 100. The rock is loaded on mill dump cars and hauled by horses over lines of track to the foot of inclined planes, which lead to the tops of the two lines of kilns. Up these inclines and along a track running over the kiln tops these cars are hauled by cables which are wound on drums located in head houses at the extreme ends of the tracks on top. The drums carry 450 feet of wire cable and are operated by Lidgerwood hoists, getting power from the mill by a rope drive. The head houses for the hoists with the sheaves and the rope drives can be seen on Figures 98 and 99. A 50-horse-power Allis-Corliss engine furnishes the power.

Figure 100.—General View of the Quarry.

Near the foot of the inclines and adjacent to the tracks leading from the quarry are coal chutes from which the fuel supply for the kilns is drawn (see Figure 99). The coal received by rail is unloaded from a high level trestle and stored in bins underneath. It is reloaded by chutes into service cars of the works, running on the quarry tracks below as it is wanted for the kilns. These cars are hauled up the inclines just as the rock cars are, and the coal is unloaded for use in bins or pockets provided between the kilns. Pennsylvania bituminous coal is used. The whole system of handling the raw materials is extremely simple, direct and efficient.

The general arrangement of the two rows of kilns with the

inclined planes and overhead tracks for the raw material, the tracks in the shed below for hauling the burnt rock and the tracks running from the shed to the second story of the mill will be readily understood from Figures 98 and 99. The kilns are continuous in operation, as is usual; though (also as usual) no work is done at night. The kilns are charged full at night and the top men report at 4 o'clock in the morning, but the regular charging and discharging of the kilns is done in a turn of 10 hours, during which the entire plant is operated. The raw rock is dropped directly in the kilns from the service cars and is spread by the top men, who add with it, layer by layer, suitable charges of coal. Below, the kilns are discharged in groups of four. When one group of four has been drawn down sufficiently the next group is drawn. In this way there is always a mixture of the product of four furnaces going through the mills, and the product is better averaged and more homogeneous than if the kilns were discharged one at a time. The wide shed has ample track room for loaded cars as they are filled up in the morning for the mill to draw on, or to store burnt rock under cover over holidays and Sundays.

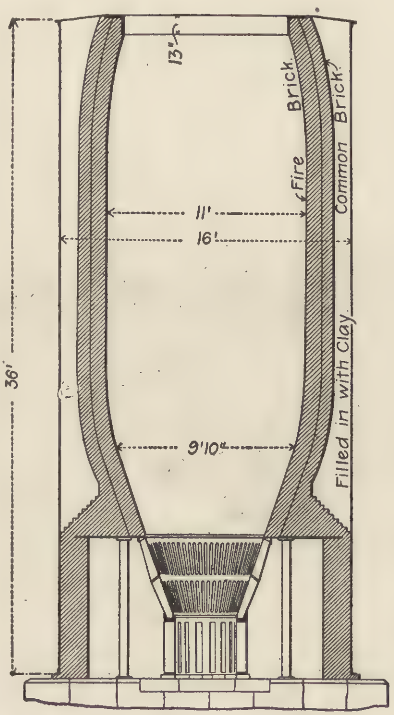


Figure 101.—Kiln with Campbell Grate.

The kilns are circular in section with sheet iron casings. As originally built, these kilns were quite similar in section to the masonry kilns illustrated in the article describing the Lawrence Cement Company's plant in Ulster County, New York (see Chapter XV.). That is, they were circular kilns drawn in to a

rather narrow hopper at the bottom with a discharging door at one side. This door was the only inlet for the draft below. A year or two ago Mr. Campbell, the superintendent of the works, reached the conclusion that this design was faulty. In drawing from the kilns some of the rock would be found hard burnt and vitrified, some normal, and some underburnt or nearly in the state in which it was charged into the kilns at the top. A percentage of underburnt coal would also be drawn below. As careful charging did not materially help this state of affairs, Mr. Campbell reasoned that a distribution of air as well as of fuel was necessary for perfect combustion, and designed accordingly a grate which could be fitted to the bottom of the kilns. This grate allowed free access of air from all sides below and distributed it equally to all parts of the charge above. Figure 101

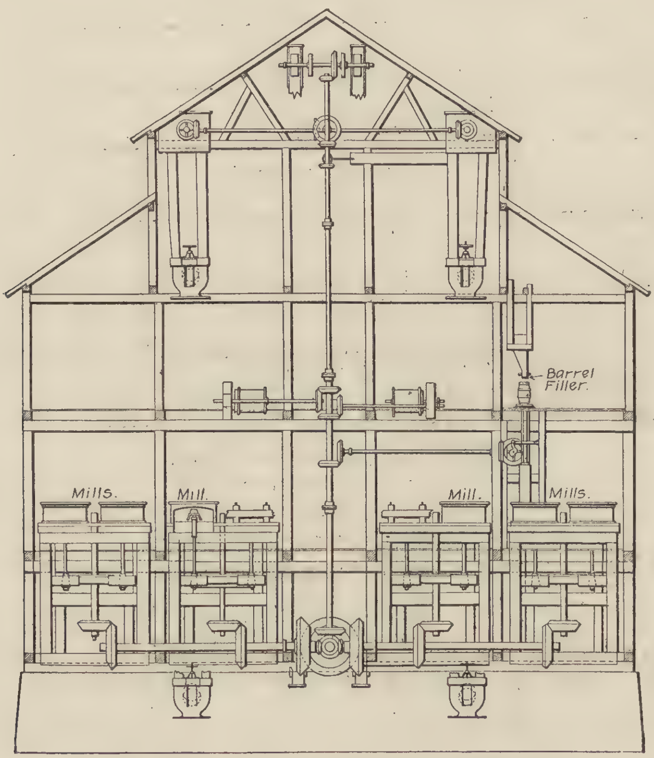


Figure 102.—Transverse Section of Mill No. 2.

illustrates these kilns as now used by the Milwaukee Cement Company, with the new grate as perfected and patented by Mr. Campbell last year. The company has been entirely satisfied with the results obtained from these grates, and is equipping its entire plant with them. With an ample draft uniformly distributed, a larger output and a much more uniform product is obtained. The free fire and more rapid combustion is alone be-

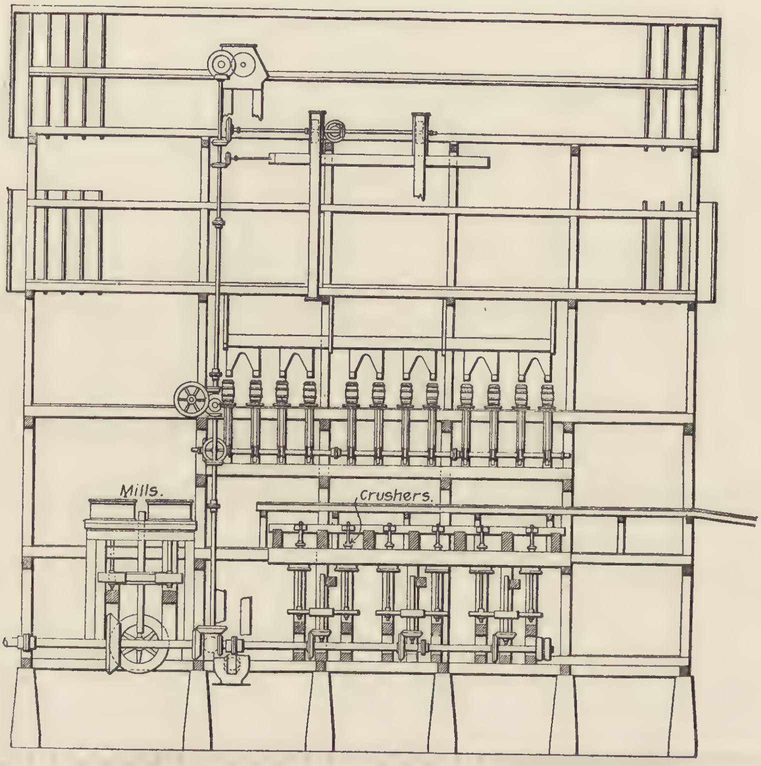


Figure 103.—Longitudinal Section of Mill No. 2.

lieved to yield better cement, grade for grade, than formerly. The construction is fully illustrated in the drawing and requires no further explanation.

The mill is illustrated in Figures 102 and 103, showing it respectively in cross and longitudinal sections. In the ground-floor plan the main driving shaft from the engine runs directly down the center of the building. All the machinery of the mill

for crushing and grinding, for conveyors, elevators, etc., takes power from this shaft by means of bevel gears. There are no belts in the mill. Directly over the main shaft and driven in pairs by gears from it are six crushers which are set in the bottom of a trough or bin on either side of which are tracks on which burnt rock is brought in. Just back of the crushers is a vertical countershaft which runs the elevators, conveyors and the hoisting drums by which cars of cement are drawn into the mill from the shed below the kilns. Still further back and next to the engine room are horizontal shafts right and left, each of which is geared to drive eight run of mill stones. These two

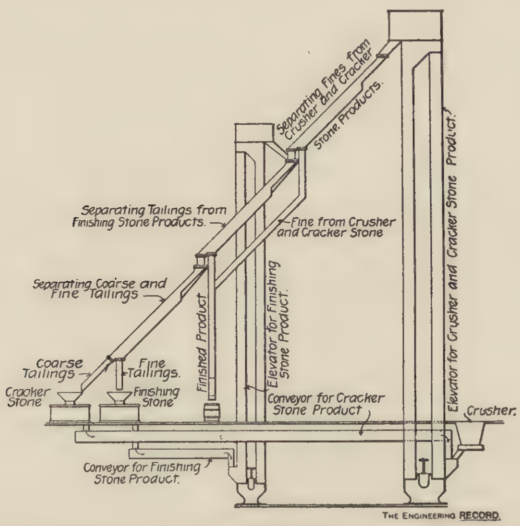


Figure 104.—The Berthelet Separating System.

shafts are in one line at right angles to the main shaft and take power from the same gear wheel. With this brief description of the plan the entire arrangement will be readily understood from the sections shown in the illustrations.

The most interesting feature of the mill is the separating system. This system is the invention of Mr. J. R. Berthelet, manager of the company, and is now widely used under license in the Rosendale and Louisville cement works and in other industries in which milling by gradual reduction is practiced. But, naturally enough, it is seen in fullest development at the Milwaukee works, where it originated. Figure 104 is a drawing

intended to illustrate the course of material in process of grinding at Milwaukee. The drawing is not in detail, nor does it represent to scale the actual arrangement. It only shows in elevation the general scheme of forwarding and separating the material. Actually, there are sometimes three runs of screens set at any convenient angle to effect one separation. It would be extremely difficult to show this in plan and elevation. Even as it is, the first impression from examining the drawing will be that the material keeps going backward or around in a circle like a kitten after its tail. To appreciate the *rationale* of the arrangement it is first necessary to imagine that material is circulating continuously through all parts of the system and then to note the two principles on which this method of separation is based. These are: First, That a coarse screen set at a steep angle will effect as fine a separation as a fine screen set near the horizontal. The screens used are 14 meshes to the inch, yet 95 per cent. of the ground cement will pass a sieve with 50 meshes to the inch. Second, That a mixture of coarse and fine must always pass over the screens together. Even with coarse screens and a steep angle it is a fact that fine stuff alone would lie on the surface and soon choke the screens completely.

With this explanation it will be understood why the fine stuff from the finishing mills is run into the conveyor that carries the cement after first reduction in the crushers, and it will be apparent that there is a continuous entry and discharge of the material and a regular discharge over all screens of a mixture of coarse and fine.

The success of this system of successive separation is remarkable. Six run of mill stones grind 2,800 barrels of cement in 10 hours, and but two of these mills have finishing stones. The other four are run with rough dressed stones and perform the work of crackers. There are eight run of stones on each side of the mill, but four of these, each side, have not been run for years. There are two cracker stones used each side and the same number of finishing stones. But of the finishing stones two only are operated at a time, while the other two are being redressed. It will be recognized from this simple statement of the facts that an extraordinary manufacturing economy has been effected by very simple means; to wit, by keeping all parts of the machinery running free on suitable material.

The separators are 10 inches wide and are inclined about 45 degrees. The top cover is placed quite near the screen, so that the coarse material in falling will alternately strike the top and rebound on the screen. Both top and bottom are lined with sheet iron. The mills are French buhrstones, $4\frac{1}{2}$ feet in diameter, the top stones being driven. The crushers employed are of the coffee-mill pattern, such as are commonly employed for this purpose.

The power plant consists of a 50 horse-power Allis-Corliss engine for driving the hoist on the kiln tops and a 350 horse-power Allis-Corliss engine for driving the mill. This latter engine is now only taxed to about two-thirds its capacity, owing to the fact that only six stones out of 16 are driven in the mill.

There are four 100 horse-power return tubular boilers (also built by the Edward P. Allis Company) supplying steam for the engines. There is a siding just back of the boiler house on a high level trestle under which the coal supply is stored for the boilers.

The works have excellent facilities for shipping, having tracks connecting with all the roads entering Milwaukee, and have a large market throughout the Northwest and in the lake cities.

CHAPTER XVIII.—THE NATURAL CEMENT PLANT AT SPEEDS, IND.

By Frederick H. Lewis, M. Am. Soc. C. E.

The so-called Louisville cements are manufactured within a radius of 15 miles of the city of Louisville, Ky., most of them at plants on the north side of the Ohio River in Floyd and Clark counties, Ind. An extensive deposit of limestone occurs at Louisville, forming the bed of the Ohio River and causing a series of falls and rapids in the stream which necessitated a canal for navigation purposes along the Kentucky side of the river, known as the Louisville and Portland Canal.

Figure 105.—View of the Open Quarry.

The first manufacture of Louisville cement began directly alongside this canal, and in conjunction with its construction, some 60 or 70 years ago. As in the Rosendale and Lehigh districts, the discovery of hydraulic properties in this limestone was an incident in the construction of the early public works. Some 13 different plants are now operated in the Louisville district, producing from 1,500,000 to 2,000,000 barrels of cement annually. The largest of these plants is the one at Speeds, Ind., which is the subject of the present paper.

The cement rock is of the same geological horizon as the water lime deposits in New York, Pennsylvania and Wisconsin. That is, it is an argillaceous silurian limestone. A general analysis would be about as follows:

	Per cent.		Per cent.
Silica and insoluble matter..	15.00	Calcium sulphate	5.00
Alumina and iron oxide......	6.00	Magnesium carbonate	10.00
Calcium carbonate..........	61.00	Water, alkalies, etc..........	3.00

The stone is of a steely gray color, compact and fine grained in texture, and occurs in working beds of 10 to 15 feet in thickness, with a stratification which is nearly horizontal. It is worked either in open quarries or by mining, as may be more economical at different localities. Thus at the Falls City Mills

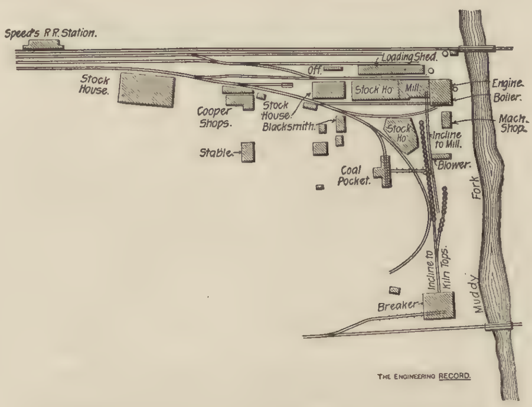


Figure 106.—General Plan of the Works.

in Louisville the deposit was worked for many years as an open quarry, but is now mined, the heading being from 100 to 150 yards from the portals. The cement rock is here overlaid by 20 to 25 feet of unproductive rock and stripping.

At the Speeds quarry the conditions are quite different as the cement rock occurs 18 inches below the soil. It is here quarried on open cut along a working face 16 feet deep. A view of this quarry is shown in Figure 105. The drilling is done by steam drills and the rock thrown down into the bottom by high explosives. A locomotive jib crane places empty skips conveniently for loading the rock and lifts loaded skips upon trucks, whence they are run by rail to the cement mill 1½ miles away. The quarry operations are quite similar to those at Milwaukee,

described in The Engineering Record of April 2, 1898. (See Chapter XVII.)

At the Speeds quarry there is no systematic breaking up of the rock for the kilns. As far as possible it is loaded as it falls. But a novel feature, for rock cement plants, is a breaker at the mills with screens for separating and grading the rock into three sizes before burning. This breaker is the point where all cement rock entering the mills is discharged and is shown in Figure 106, a general plan of the works. Figure 107 is a view of the works. Figure 108 is a view of the breaker, the cars from the quarry entering the top at the right of the picture.

Figure 107.—The Speeds Mill.

Mr. Cook, the general superintendent of the plant, is a great believer in economy of manufacture, and finding that the fine stuff calcines more readily than heavy rock, he effects the two separations, making three grades of stone at the breaker, and under the inclined planes which run from the crusher to the kiln-tops has placed a series of low kilns of such heights as the clearances will permit. The low kilns are used for the calcination of the finer rock.

From an examination of the general arrangement of the plant and the method of handling materials, it will be apparent that in its arrangements for the direct and economical handling of

material this plant is of unusual excellence. Neither the rock, the fuel nor the clinker is handled at all by manual labor at any point in the process of manufacture. As the rock is separated automatically at the breaker into grades A, B and C it drops into service cars below. These cars are hauled by cable up an incline, shown in Figures 106 and 107, to the kiln tops and discharge through copper bottoms directly into the kilns. The coal for calcination is discharged on its arrival by rail into trestle pockets, which discharge below, into service cars. This is shown by Figure 106, the general plan, and Figure 109, which is a vertical cross-section through the tracks over the double

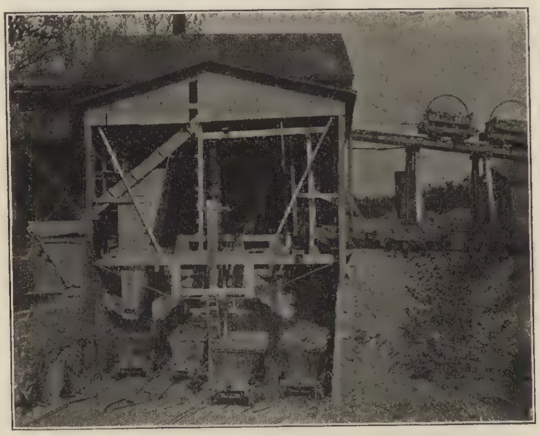


Figure 108.—View of Breaker.

row of kilns. The coal pockets are at the bottom and right. Coal cars are drawn up an inclined plane and discharged into a hopper bottom pocket set high above the kiln tops. Service cars running over the kilns draw on this hopper as coal is required and deliver it to the kilns. These coal cars are provided with a spraying device worked by crank and pinion so as to spread the coal in discharging it uniformly over the kilns. Finally at the base of the kilns, the burnt rock is drawn out upon chutes or inclined planes provided in the masonry foundations and discharges down these chutes directly into cars below. Thus neither in the yard nor in charging rock and fuel above, nor in discharging clinker below, is there any lifting of material

by labor. Figure 110 shows in plan and elevation one of the kilns and the track for conveying the burnt rock to the mill.

The milling and packing arrangements are planned in quite the same way, so that it is literally true that after raw materials are delivered to the mills there is no handling in any stage of manufacture until the cement is in the package ready for shipment. Figure 111 gives two views at right angles to each other, showing the delivery of burnt rock to the mill and the course it follows in milling. The detail is ample and illustrates very

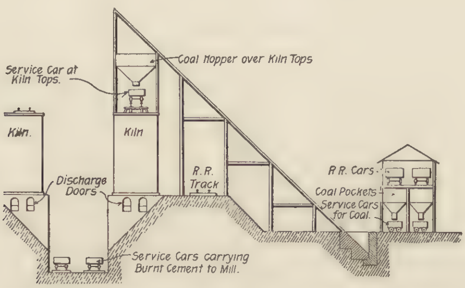


Figure 109.—Cross-Section at the Kilns.

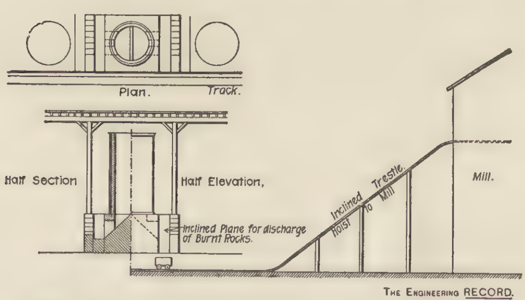


Figure 110.—Plan and Elevation Near Mill.

fairly the Berthelet system of gradual reduction and separation employed in the West for milling natural cements. The methods peculiar to this system are the use of coarse screens set on steep inclines; a separation after each reduction; and passing over the screens at each separation of a mixture of coarse and fine material. Operating in this way the screens effect a fine separation, wear well and never clog, and the amount of material which must be ground on finishing mills is reduced to a

fractional part of the whole output. Four hundred barrels per hour can be ground at Speeds, running but five mill stones.

The barrel and bag-packing machinery at Speeds is complete and automatic. A new device by which bags are secured to the spout by an expander in the end is simple and efficient. The kilns at Speeds are 16 feet in diameter outside, have a sheet-iron casing and are lined with 4 inches of clay backing and 13 inches of fire clay brick. This leaves an inside diameter of 13 feet. The height above the masonry setting is 30 feet. These kilns will produce 250 barrels of cement per day (265 pounds net per barrel, Western standard). The fuel is Pennsylvania or Kentucky bituminous coal, the former preferred.

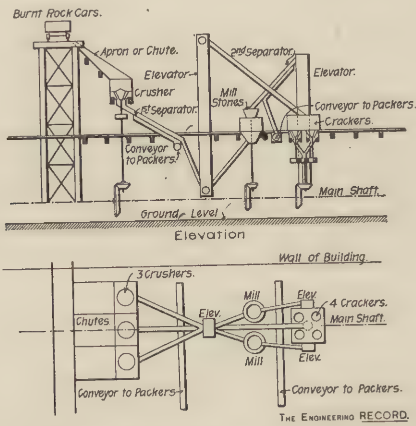


Figure 111.—Method of Milling.

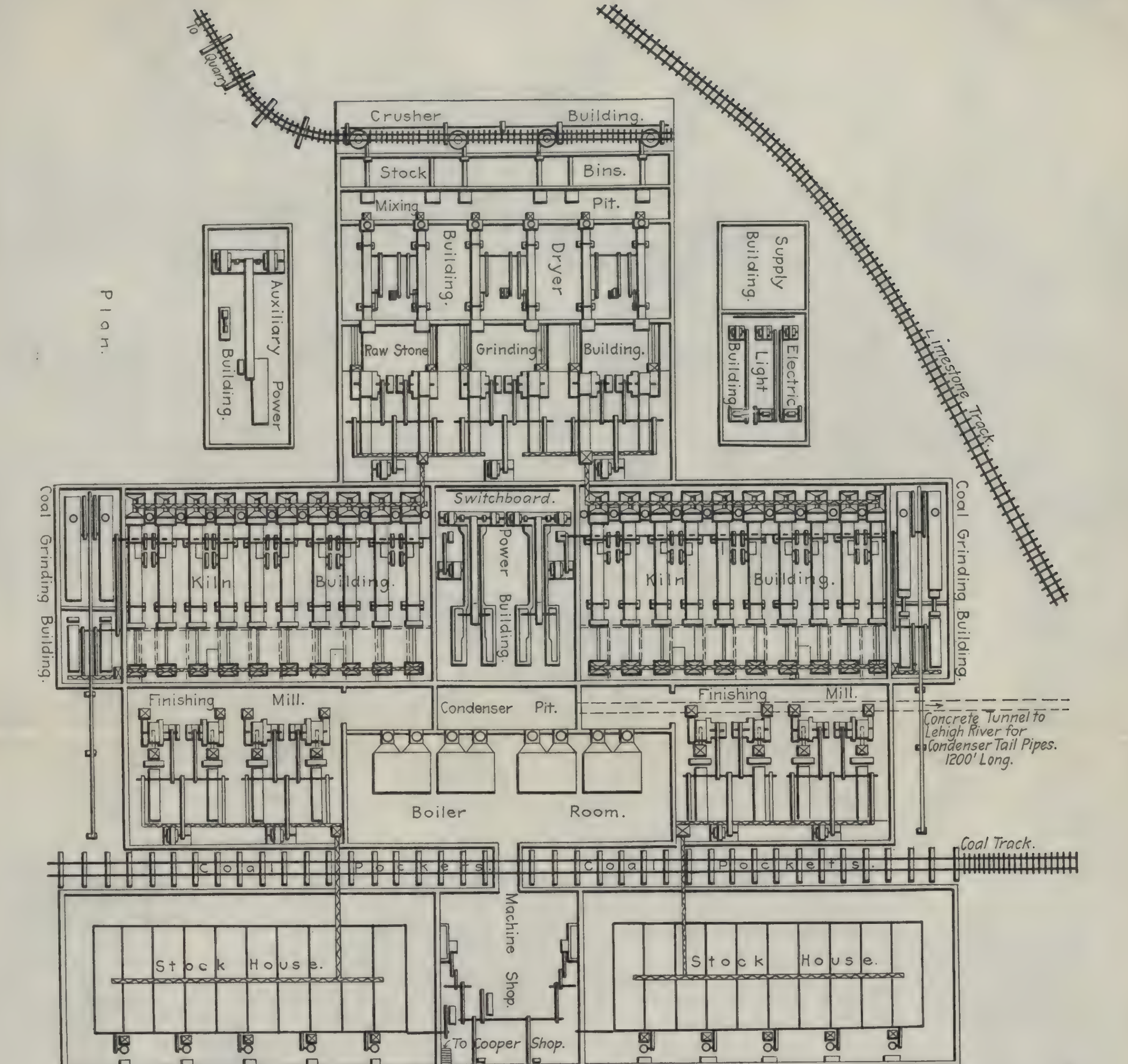
Mr. Cook has several kilns fitted up with forced draft, from which he obtains an output 33 per cent. greater than with natural draft. The economy of fuel is, however, small, as the open top kilns charged full do not retain or hold the heat well. The power plant consists of 750 horse-power of Babcock & Wilcox water-tube boilers, one 300-horse-power Allis-Corliss engine and one 600-horse-power Corliss engine built in the company's shops. The product of the plant at Speeds is sold by the Western Cement Company of Louisville, Ky., as the "Star Brand" of Louisville cement.

CHAPTER XIX.—THE PLANT OF THE MARYLAND CEMENT COMPANY, SPARROWS POINT, MD.

By Frederick H. Lewis, M. Am. Soc. C. E.

The Maryland Cement Company built a plant at Sparrows Point in 1898 for the manufacture of hydraulic cement, and this year is largely increasing its capacity. The principal raw material employed is slag from the blast furnaces of the Maryland Steel Company, hence the choice of a site along the waterfront immediately opposite the steel company's furnaces. The cement plant thus shares the same shipping facilities as the steel company by rail over the Pennsylvania Railroad or by deepwater navigation on Chesapeake Bay. As the output of slag from the blast furnaces is normally about 1,200 tons per day, the supply of raw material is practically unlimited so long as the iron plant remains in successful operation. Hence the cement company has a direct stake in the iron market—a condition of affairs which need not under present conditions occasion its owners the least anxiety.

The manufacture of hydraulic cement from furnace slag has been exploited and investigated considerably abroad, but is a new industry here. The plant at Sparrows Point is the second one only in this country to place slag cement on the market in any considerable quantity. It was built for the company by Mr. John L. Given, following precedents and practice developed by similar manufacture in Europe. Without going at length into the conditions of manufacture of cement from slag, it may be said briefly that it is only occasionally that ores and fluxes employed in blast furnaces will produce slag suitable for cement. The products of a large majority of the furnaces in this country would probably be found unsuitable from one cause or another. It may be further explained that furnace slags as ordinarily produced by casting and cooling slowly from a state of fusion are one and all devoid of hydraulic properties. It is necessary that a change of composition may be effected by brusquely cooling



Figures 83 and 84.—Plan and Sectional Elevation, Whitehall Portland Cement Works, Cementon, Pa.

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the slag from a state of fusion. Treated in this way certain slags show decidedly hydraulic properties.

At Sparrows Point, Cuban iron ores are largely employed for reduction in the blast furnaces with oyster-shells as flux. The slag produced necessarily varies more or less, but a large part of it is found to conform satisfactorily to established criteria for cement slags. The first step in manufacture takes place at the blast furnaces. Slag which is to be used for cement is run off from the furnaces and drops in a molten state into a trough through which a large stream of cold water is forced. Brusquely chilled by the cold water, the slag solidifies in vesicles or bubbles, which break up into thin, shell-like pieces. These are carried by the water into a car and deposit there as the water drains away. The best grade of slag has a delicate blue color and, though hard, is thin, porous and readily crushed into fine stuff in the hand. In this condition the slag is delivered to the cement company as the major raw material for its manufacture. The minor constituent in the cement mixture is slaked lime, and the process is extremely simple. It consists of the following steps: 1, drying the slag; 2, mixing it with such proportion of slaked lime as may be desired; 3, grinding the mixture to a very fine powder. This powder is the finished product—a hydraulic cement.

The arrangement of the plant at Sparrows Point to conduct this scheme of operation is shown by Figure 112. The dryer which is shown at the left-hand corner of the figure was built by the Ruggles-Coles Engineering Company, of New York, and is arranged so that the fire door of the dryer furnace opens on the boiler room and the fireman in charge of the boilers can also maintain the fire for the dryer. The granulated slag is wheeled from the yard in barrows and dumped into an elevator boot (not shown) which discharges into the top of the dryer. Owing to the method of water cooling which the slag undergoes at the blast furnace, it contains a large percentage of water and requires very thorough drying. This result is achieved very satisfactorily with the Ruggles-Coles machine. Immediately to the left of the dryer house is a shed in which the lime is slaked; the ingredients are then elevated to the second floor of the mill building, mixed in suitable proportions and discharged into closed pebble mills. These mills are revolving steel drums con-

taining flint pebbles. The charge is admitted through a manhole which is securely fastened to the mill and each charge is ground for the same period of time. The manhole cover is then removed and the contents of the drum discharged into a conveyor which runs along the front of the mills.

It is considered necessary at Sparrows Point to adopt the closed mill of the type described above in order to secure a homogeneous product. The slag, being harder and rather heavier than the slaked lime, would grind much slower, and it was anticipated that in a continuous mill there might be a tendency of the lime to segregate. There are seven of these pebble mills

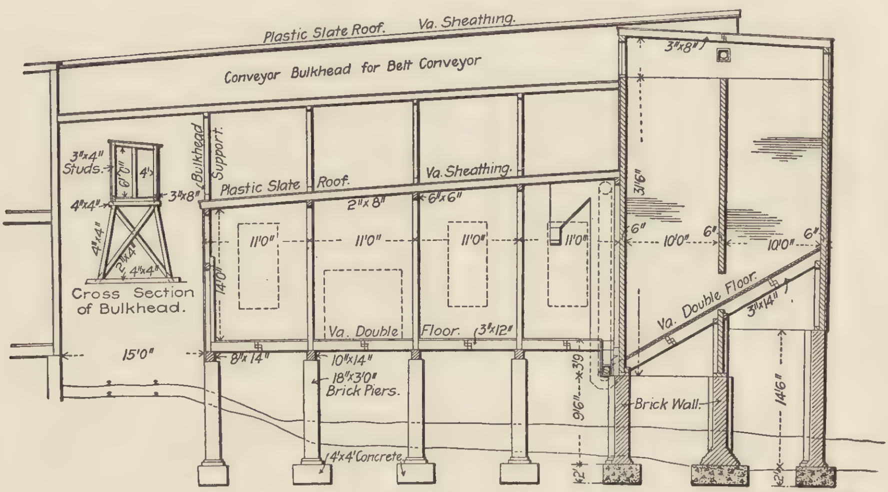


Figure 113.—The New Storage Building.

driven from a line shaft in the rear. The countershafts of the mill are all on friction clutches so the mills can readily be stopped and started.

Power for this mill and the elevating and conveying machinery is provided by a Greene engine of 500 horse-power capacity; the steam is supplied by two return tubular boilers. The extension of the plant for this year is shown by the seven new mills directly opposite the old ones and by the installation of a new dryer, which will practically double the capacity of the plant.

The product of the mills, as noted above, is discharged into a conveyor in the basement, which in turn discharges it into an

elevator boot and the ground cement is then raised to the second floor of the mill. A good deal of packing is done on the second floor by hand labor, the rest being done by a Silver Creek packer on the floor below. In order to provide handling and storage facilities for the new plant, a separate building has been designed, which is shown in Figure 113. When this is constructed the plant will have a large storage capacity and facilities for handling cheaply an increased output.

The writer is indebted to Mr. Frank H. Sloan, president, and to Mr. John L. Given, engineer, for the opportunity to describe this plant for The Engineering Record.

CHAPTER XX.—THE AMERICAN ROTARY KILN PROCESS FOR PORTLAND CEMENT.

By Frederick H. Lewis, M. Am. Soc. C. E.

It is probable that in the great group of primary manufactures nothing is attracting more general attention and interest at this time than the rotary-kiln process for cement. To compare it with the Bessemer process, which so enormously increased the output and decreased the cost of steel, would be to exaggerate the facts, yet, dealing with smaller factors, the rotary kiln is advancing the cement industry in America on quite similar lines. The facts in regard to the production of different types of cement kilns are as follows:

Intermittent kilns	15 to 30 barrels per day
Continuous shaft kilns.....................	40 to 80 " " "
Rotary kilns require	30 to 40 per cent. of fuel (coal)

In conjunction with this large output from rotary kilns there is an even more marked decrease in the labor cost, not only in the manipulation of the kilns, but in the preparation of raw materials and in the handling of clinker. In fuel consumption, on the contrary, rotary kilns are not economical, for reasons which will appear later. A comparison in this respect would be about as follows:

Intermittent kilns require	25 to 35 per cent. of fuel (coke)
Continuous shaft kilns require	12 to 16 per cent. of fuel (coal)
Rotary kilns require.................	30 to 40 per cent. of fuel (coal)

Dismissing the intermittent kilns as an obsolete type, a comparison of costs under American conditions between rotary and continuous-shaft kilns would be somewhat like this, the figures being only for handling kilns and those kiln accessories which differ in the two processes:

	Rotary kiln.	Continuous shaft kiln.
Labor cost per barrel..........	2½ to 4 cents	12 to 14 cents
Fuel cost per barrel............	11 to 15 cents	5 to 6 cents

To complete the comparison, there must be added to the figures for shaft kilns the further sum of 1.25 cents per barrel, representing the interest on the greater cost of a shaft-kiln plant. It requires five shaft kilns to equal the product of two

rotaries, while the cost, kiln for kiln, is rather less in the rotary plant. From the data presented there is apparently a present economy of several cents per barrel in favor of rotary kilns, with the economics of the process by no means yet exhausted. It will be seen, too, that the rotary kiln is advancing the industry on exactly those lines which have established economical production in other great industries in America, and which are necessary under American conditions, viz., the susbstitution of fuel and power for labor.

Under the stimulus of a suitable process, the American Portland cement industry is developing at an extraordinary rate. The rotary kilns already installed and operated have an annual capacity of quite 3,000,000 barrels, and the new plants building and projected seem likely to double this capacity within a twelvemonth. In 1899* the greatest cement-producing plant in

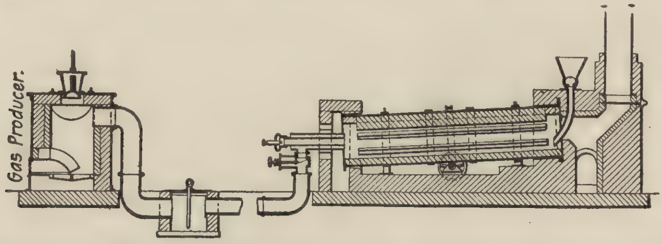


Figure 114.—The Original Rotary Kiln; Ransome's Patent of 1885.

the world will be that of the Atlas Portland Cement Company, now operating 29 rotary kilns in the Lehigh Valley and building others.

The introduction of these kilns abroad is receiving general attention from progressive men, and at several points experimental rotary kilns are under way, while one large enterprise is being exploited.

Rotary furnaces for one purpose or another have been used for many years, hence there is nothing new or novel in this general type of furnace. In 1885, however, Mr. Frederick Ransome patented in England a plant of this kind for cement-making purposes. An American patent was issued to him in the following year, and in Figure 114 will be found a copy of the drawing attached to his American patent. His claim under this patent is substantially for the calcination of cement in a rotary

*This article was written late in the year 1898.

furnace by means of gas. His device, as will be seen, is a cylinder made of boiler iron and lined with fire bricks. It is set at a slight inclination to the horizontal, carried on roller supports at two points, and turned by rack and worm. The wet raw materials usually employed in England had to be previously dried and ground and were introduced into this kiln in the form of powder. The forward movement of the material resulted, of course, from the revolution of the inclined cylinder. The material, which was carried up the sides by the motion of the kiln, fell forward under the action of gravity through an angle represented by the pitch of the kiln. Thus it slowly advanced in a zigzag course from one end to the other.

In type this kiln is quite the same as those now employed here. But as built in England they were much smaller in diameter and much shorter than those now used. These kilns were

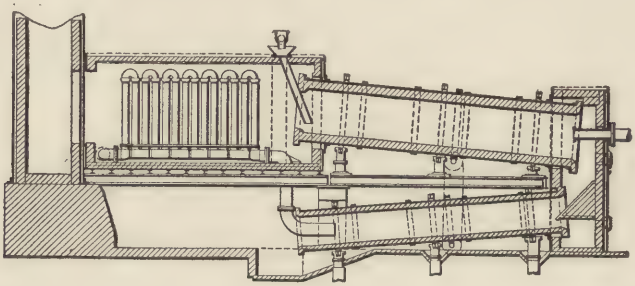


Figure 115.—Navarro's Improved Kiln of 1891; First American Practice.

very fully exploited at the Gibbs works at Gray's on the Thames, some 30 miles below London, and kilns of Ransome's design were built at a number of other places in England. They were, however, found practically unsuccessful, chiefly because of the balling of clinker on the lining and the inequality of the product. It was also probably much more expensive in fuel than was anticipated. For these reasons the process was abandoned in English cement works.

The Atlas Portland Cement Company in this country was organized at the time Ransome was introducing his kilns in England, and, becoming interested in this system, introduced it in this country, first in a plant on the Hudson River near Rondout, and later, with more favorable raw material, at Coplay, in the Lehigh Valley of Pennsylvania. The hard, dry, raw materials found

at Coplay were admirably suited to the rotary-kiln process. Nevertheless many practical difficulties were encountered, and there was an immense amount of expensive experimenting required before correct and economical practice could be established with rotary kilns. Without in any way detracting from the work of others, the chief factor in the successful development of the rotary process has unquestionably been the Atlas Portland Cement Company, and to its proprietors the credit may be freely accorded.

Figure 115 illustrates the patent taken out in 1891 by Mr. J. F. de Navarro, of the Atlas Portland Cement Company, for a system of regenerating the heat of the kilns and securing greater economy in fuel. It will be seen that there is a hot-air stove in the chimney flue and an auxiliary cylinder for receiving and cooling

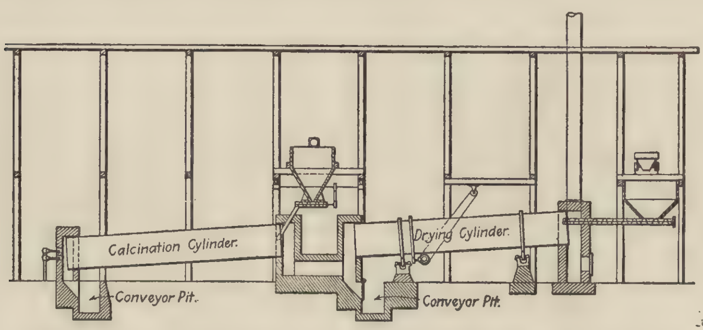


Figure 116.—First Kiln fcr Wet Materials, Warners, N. Y.

clinker. The air for combustion passes first through the stove and then over the hot clinker, reaching the kiln in a heated condition. It is stated in the patent that this regenerative system is to be used in conjunction with gas fuel. This would indicate that gas was still employed as fuel in 1891, and, further, that it was expensive—very much more so, no doubt, than had been claimed in England, where the coal required for the gas producers had been estimated to be 16 to 20 per cent. of the cement produced. Not long after this, crude petroleum was substituted for producer gas as fuel for rotary kilns, evidently with advantage, since it superseded gas entirely and was the only fuel employed from about 1892 to 1896. Oil is still used, but is being displaced in turn by powdered coal, which is more economical.

In Figure 116 will be found a general sketch of the first ap-

Figure 117.—Interior of Kiln Building, Warners, N. Y.

plication of rotary kilns in America to wet raw materials, as built by the Warner Portland Cement Company in 1892. It will be seen that Ransome, employing wet raw materials, expected to dry them by some separate process. At Warners this was improved upon by utilizing the high temperature of the chimney gases. In this plant the clay and marl were dried in separate cylinders, and then mixed by weight and the mixture ground to powder before introduction into the kilns. The kilns and drying cylinders were each about 40 feet long.

Figure 117 is a photograph of the interior of the Warners plant, in which the drying cylinder occupies the foreground of the picture.

Figure 118 illustrates another scheme for effecting economy of fuel in rotary kilns, a matter which has received almost continuous attention. This figure is taken from a paper read by

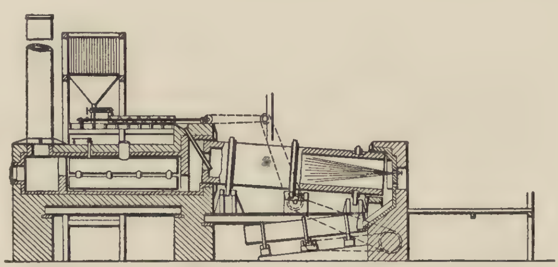


Figure 118.—Kiln Proposed by Giron, 1893.

Mr. Giron, formerly superintendent of the Atlas Portland Cement Company, before the Engineers' Club of Philadelphia, in April, 1893. (See the "Proceedings" of the Engineers' Club of Philadelphia, Volume X, number 3.) It shows the cooling cylinder for clinker which appears in Mr. de Navarro's patent of 1891, but in place of a hot-air stove in the chimney flue, Mr. Giron has substituted a boiler. It is interesting to record that in spite of these suggestions for utilizing waste heat very little has been practically accomplished in this direction. The kilns are now used with little or no attempt to utilize the heat of chimney gases, while the heat of the clinker is utilized to a very limited extent, and, as a matter of fact, when the latter is done its purpose is more to cool the clinker than to utilize the heat. Indeed, it can be shown that if the entire heat of the clinker could be regenerated to heat the air required for combustion, it would only heat this

air to about 250 degrees Fahrenheit. Practically, of course, no such result could be expected. The chimney gases, however, present much greater possibilities for the regeneration of heat, and practical results in this direction are to be expected in the future.

In the paper mentioned above, Mr. Giron claimed great advantages from a preliminary calcination of the raw materials, sufficient to drive off the carbonic acid, before they were introduced to the kiln proper. He said: "The absence of carbonic-acid gas in the materials facilitates wonderfully the operation of the rotary kiln. The output of burnt cement is doubled and the consumption of oil reduced nearly one-half, compared with the amount required for raw materials. This combination will prove economical where coal is cheap and crude oil expensive."

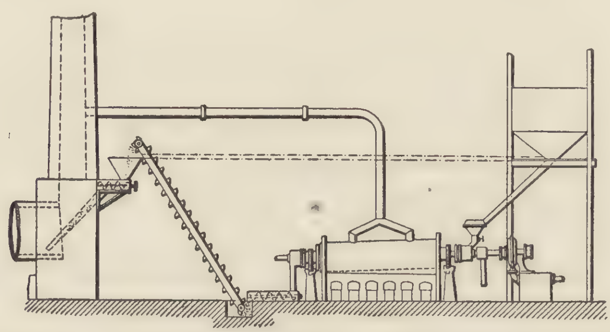


Figure 119.—Navarro's Preliminary Calcination System, 1896.

If this view is correct it is of the highest importance, but an examination of the facts in the case leads to the conclusion that Mr. Giron probably based his opinion on insufficient data. It is true that when operating on raw materials in their natural state, 200 pounds of volatile matter must be lifted out of the chimney for every barrel of cement produced. But when it is considered that the products of combustion, including the nitrogen and the free air which are inevitably present, amount to something like 2,000 pounds per barrel of cement, the relative importance of the volatile matter in the cement mixture is seen to be small. When, too, it is considered that at least two-thirds of the theoretical value of the fuel is lost by radiation, dilution and as unutilized heat, it is difficult to believe that the absence of carbonic acid would effect much economy of fuel, especially

since the temperature required to clinker the cement remains the same.

It is interesting, however, to find that Mr. de Navarro has taken out a patent for the preliminary calcination of raw materials, as shown in Figure 119. This device is extremely ingenious, in that it not only proposes to drive off the carbonic acid, but to collect and utilize it. It consists of a revolving drum, heated externally by a coal fire. The cement mixture passes through the drum and the carbonic acid which is expelled is drawn out by an aspirator and collected in the receptacle shown to the right of the drawing. The material, free from carbonic acid, is carried by conveyor to the rotary kiln at the left. So far as the writer knows, this device has not been practically applied on any large scale.

As showing the state of the art in England, Figure 120 is reproduced here from a review of English cement practice written

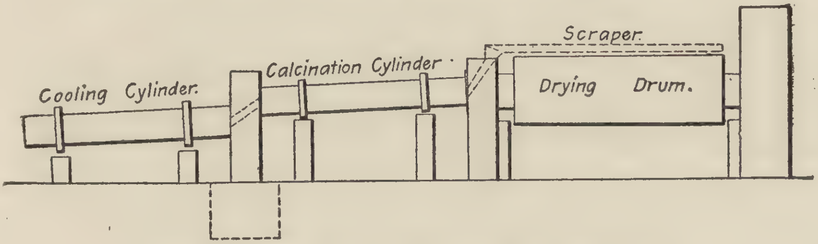


Figure 120.—Stokes System for Wet Materials.

by Messrs. Stanger & Blount, of London, for the "Mineral Industry" of 1896. This is the Stokes process for wet, raw materials. The calcination cylinder and the cooling cylinder are readily understood. The peculiarity of the device is in the large drying drum. This is 12 feet in diameter and 40 feet long. It is unlined, and the products of combustion, passing through it, come in direct contact with the metal shell. The wet slurry is deposited continuously on the descending side of the drum as it slowly revolves, while a scraper conveyor removes the (supposedly) dried slurry which forms a crust on the ascending side. This device fairly represents the advance which has been made in England since Ransome first brought out his kiln in 1885. At the present time there is practically no manufacture of cement in rotary kilns in England, and if they are presently introduced there they will be built on American plans.

Figure 121 shows the type of kiln setting patented in 1895 by Messrs. Hurry & Seaman and employed as a process of manufacture by the Atlas Portland Cement Company. The purpose of this arrangement is to cool and cure the clinker regularly and rapidly. Dismissing the kiln proper, which in the drawing pre-

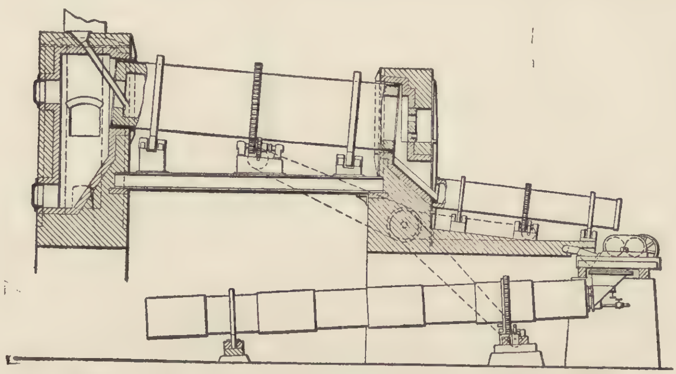


Figure 121.—Hurry & Seaman's Kiln Setting, 1895.

sents no peculiarities, there are seen to be two auxiliary cylinders for cooling clinker. The first of these receives the clinker as it falls from the kiln, and is set so as to induce a draft over the hot clinker into the kiln. From this cylinder the clinker falls on water-cooled crushing rolls, discharging by a chute into the lower cooling cylinder. A strong draft is induced through the lower cylinder, so as both to cool and dry the clinker. The detail of this arrangement is shown in Figure 122. In this drawing is shown a sprinkling device below, in addition to the sprinkling which takes place at the crushing rolls. This scheme is excellent, both as a means for cooling and curing clinker and as a labor-saving device for handling it. It constitutes an important improvement in the rotary-kiln process.

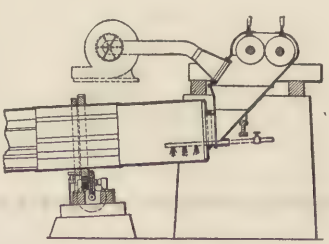


Figure 122.—Crushing and Sprinkling Device of Figure 121.

Figure 123 illustrates the extremely simple scheme now adopted for burning wet, raw materials in rotary kilns. The wet slurry contained in the tanks shown to the left of the drawing is

introduced into the kiln by a pump. The motion of the kiln and the heat it contains successively accomplish the drying of the slurry, the expulsion of the carbonic acid and the clinkering of the cement. The hot clinker drops in a slender stream from the lower end. The simplicity of the device is such that no one would have thought of it at the outset. This arrangement was gradually reduced to its present form in the course of some years' manufacturing with wet, raw materials at the Sandusky plant in Ohio. Most of the features shown in the drawing were thus developed at Sandusky.

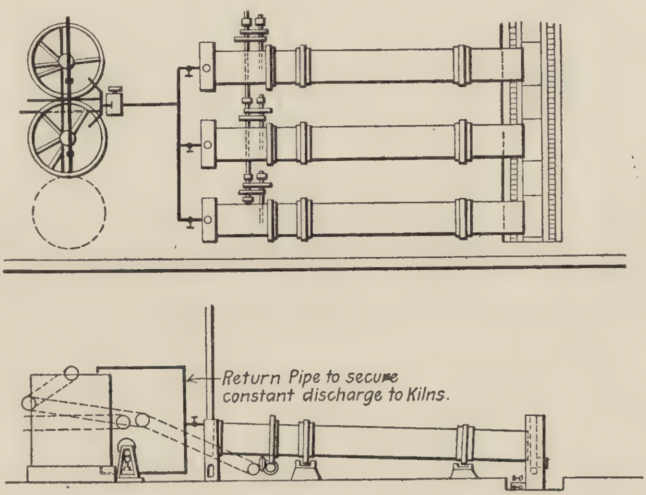


Figure 123.—Recent American Kiln for Wet Materials.

Figure 124 illustrates in section the type of kiln and kiln setting ordinarily found now in plants operating on dry, raw materials. In essentials it differs very little from Ransome's. The kiln is very much longer and larger than in early practice, the fuel is powdered coal, the handling of the plant is entirely by mechanical means, the kiln has been reduced to an efficiency and an economy which are greater, under American conditions, than any other, and its further possibilities in this direction are considerable.

The rotary kiln is uneconomical in fuel for several reasons. The first of these, no doubt, is the introduction of a large excess of air at the lower end, due to some extent to the necessity

for revolving the kiln. The second is the loss by radiation from the large surface of the iron shell. This can be remedied by heavy linings, since it is desirable to keep the shell cool, and therefore impracticable to cover it with non-conductors. The third is in the free escape of gases at high temperature to the chimney. Considering, then, the first and third, there are evident opportunities for economy, both at the front and at the back of the kilns. Generally there is more draft induced than is necessary, and more chimney area than is required. The volume of gas passing through under good conditions of combustion, without excessive dilution of air, is not large, and the velocity of the gases passing through is slow. *Per se* these conditions favor both the generation and the regeneration of heat, and it may safely be predicted that there will be a development of economy in both.

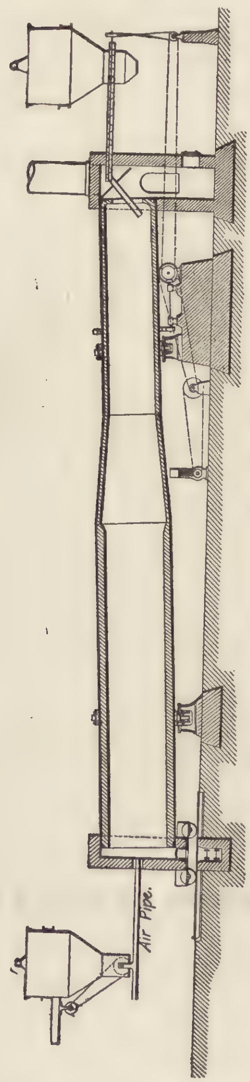


Figure 124.—Recent American Kiln for Dry Materials.

Very vague notions are entertained of the rapidity of calcination in rotary kilns. It is commonly assumed that the material passes through in half an hour. The transit of the material through the kiln is due to its falling in a vertical plane under the action of gravity from the side of the kiln as it revolves. Assuming that the kiln has a pitch of half an inch per foot, that its diameter is $4\frac{1}{2}$ feet inside the lining, and that in falling the material passes over an arc of 90 degrees, then at each quarter turn of the kiln (90 degrees) the material will fall forward $1\frac{1}{8}$ inch, or for each full revolution $5\frac{1}{8}$ inches. If the kiln is 60 feet long, the time of transit will then be $60 \times 12 \div 5\frac{1}{8} = 140$ revolutions. It could not possibly move any faster, as

any time occupied in falling would be lost in revolving. Revolving at one turn a minute, which is the ordinary speed, between two and three hours are thus indicated as the time of transit. This being so, a kiln producing 6½ barrels of cement per hour will carry a charge in transit of about 4 tons of material.

Compared with shaft kilns of either the intermittent or continuous type, which require from three days to a week for the process of calcination, the rotary process is extraordinarily rapid. It might be, and has been, assumed that this was a disadvantage, and that the slower processes were better, and there was not lacking in the earlier work of rotary kilns some grounds to sustain this view, but the view now generally entertained, both by experts at home and those from abroad who have examined the process, is that with a correct and homogeneous mixture the rapid calcination is an advantage.

The chemical union seems to be more perfect and the percentage of active cementing material rather greater. For example, in shaft kilns under slow calcination there is generally a certain percentage of clinker which disintegrates, falling into inert dust, without hydraulic activity. When the percentage of lime runs a little too low there is a considerable quantity of this dust. Now, this phenomenon does not occur with rotary cement clinker, or, at least, is extremely rare, indicating a chemical union which is stable, and a greater percentage of active hydraulic material in the product.

The high temperature of the rotary kiln is peculiarly adapted to the hard, raw materials of the Lehigh Valley, which are comparatively free from fluxing salts, and it has worked well with similar wet, raw materials in Ohio and Michigan. Whether it can be as successfully applied to materials containing the high percentages of fluxes which are found in some of the European mixtures is, perhaps, questionable. It is possible that for such materials shaft kilns are better. With this exception, however, the rotary kiln seems to have advantages for American conditions which cannot be questioned.

CHAPTER XXI.—PLANTS IN ENGLAND AND BELGIUM.

By Frederick H. Lewis, M. Am. Soc. C. E.

The most interesting fact at this time in regard to Portland cement in England is that the manufacturers have awakened to the necessity of improving their products. For twenty years methods of manufacture in England have remained practically unchanged, and the product changed as little as the methods. Portland cement was discovered by an Englishman; it got its name in England, and for a quarter of a century its manufacture was wholly an English industry. The traditional policy of the manufacturers toward foreign trade has therefore been simply this: "Here is our cement as it has always been made; you can take it or leave it, for we make nothing else."

With the rise of the German cement industry, many foreign buyers have accepted the alternative, and German cements have displaced the English product in many export markets and quite generally command a premium in price. This appears to have gone on without action in England until about two years ago, when the cement industry reached a crisis of small sales, little or no profit and financial stringency. Since then there have been large consolidations of interests, a better understanding in the trade, and a live interest among progressive men in studying the demands of export markets.

To American minds it must appear most extraordinary that manufacturers in England should have seen trade slipping away for years, and from sheer conservatism have been unwilling to take any steps to stop a loss both of business and of prestige. The real fact is that there have been several factors at work to bring about this state of affairs. The Englishman is conservative, but no one who knows the shrewdness of English business men can believe that they have let business decline from mere obstinacy. Two other factors which have contributed to the result described above are: 1. The conduct of manufacturing under land leases. 2. The obstinacy, not to say pig-headedness, of the English laboring classes.

The fabric of English law has been accumulating for centu-

ries, much of it yet uncodified, and it is a veritable maze, which Dickens declared to be inexplicable until viewed from one standpoint. When you consider it as a device for making business for lawyers, the whole thing at once becomes perfectly clear. It is a real bar to change to an extent which is hardly realized in America, and in manufacturing, as well as in agriculture, it evidently makes the improvement of leased property a matter for serious consideration.

The stubbornness of English labor in adhering to time-honored methods, and the power of the labor unions and of the close trades, has often been commented on before. While the labor in England is energetic—"smart"—it evidently has more power and is harder to deal with than in either America or on the continent of Europe. In a comparatively close industry like cement making, with the traditions of sixty years behind it, it evidently requires unusual vigor and determination to enforce new methods of work.

At this writing this change of policy, inaugurated two years ago, has resulted in two changes of manufacture. The first is in putting finely ground cement on the market. It used to be considered quite good enough in England to grind cement so there should be a residue not exceeding 10 per cent. on a No. 50 sieve (Am. Soc. C. E. standard). Such cement gave good results in tests of neat briquettes, but when tested, as in Germany and America, in mixtures of 1 cement to 3 sand, the results were at least 30 per cent. to 40 per cent. below the figures obtained from finely ground cements. The sand-carrying capacity was essential, but was not there.

To show what English manufacturers are now prepared to do, the following figures of a recent lot of cement shipped to America are here given:

99.9	per cent.	passes	No.	50	sieve.
95.0	"	"	"	100	"
78.0	"	"	"	200	"

These figures are in excess of any standard for fine grinding which has come to the writer's attention, and mark a really important improvement in quality.

The second improvement is in making cement with a setting time to suit the conditions under which it is to be used. The old idea that a cement which was good enough for England was good enough for anybody is found to be an assumption

which is neither true nor reasonable. It proves to be a fact that a cement which, in the moist, cool climate of England, will set in, say, 45 minutes, and which can be satisfactorily used there for any purpose, will, in the warm, dry atmosphere of an American summer, set in from two to five minutes, and be quite unfit for laying sidewalk, or for any but rapid work. From a careful comparison of data in England and on the Continent the

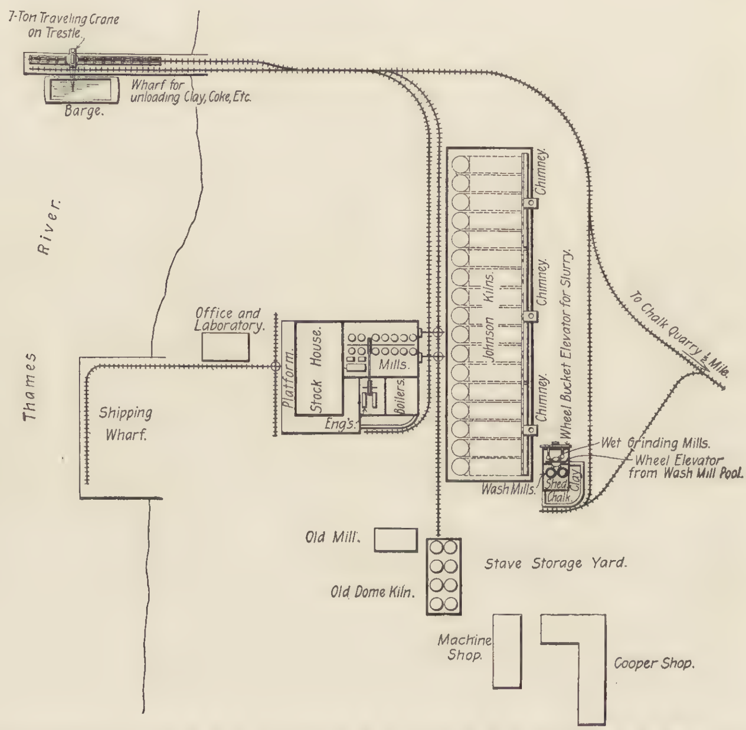


Figure 125.—Plan of the Cement Works, Grays, Essex.

writer finds that cements leaving Europe with a setting time of from five to eight hours will, in America, set in less than half these periods. Such changes appear to be quite marked even in winter, when the climatic differences are not great; but they are, of course, much more marked in summer. Even with very great care very queer changes in setting-time take place in Portland cements, and the most experienced manufacturers

are occasionally nonplussed to account for them. These facts have been receiving great attention from at least two leading English manufacturers in the last two years, and they now declare themselves ready to furnish whatever their customers may desire in this respect.

Taken in conjunction with the fine raw material of the Thames and Medway, these two improvements evidently go a long way in improving English cement.

The Works at Grays, Essex.

Through the courtesy of Messrs. Hilton, Anderson, Brooks & Company, the writer had an opportunity to visit in detail their works at Grays, under the guidance of the resident director, Mr.

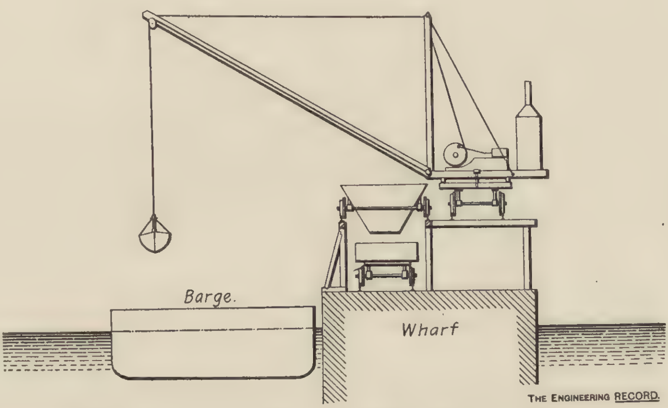


Figure 126.—Brooks-Shoobridge Wharf Crane.

Alfred Brooks. The present firm was formed by a union of the old firms of Hilton, Anderson & Company, and Brooks, Shoobridge & Company. They have four plants, two of them small; the other two, at Grays, on the Thames, and Halling, on the Medway, are quite large plants. The firm produces annually about 800,000 barrels of cement, and has the largest American trade of any English house.

The works at Grays are directly on the Thames, some 22 miles below London, and are shown in plan in Figure 125. Vessels of moderate draft can load directly at the wharves. The clay comes from the mouth of the Medway, some miles below, and is very expeditiously unloaded from the barges by means

of a clam-shell dredging bucket which is carried by a 7-ton jib crane. The crane runs on a high-level track on the wharf and drops its load into cars running at a lower level alongside the barge. It is by turns yellow or blue in color, but quite pure and free from foreign matter.

The chalk quarry is in the hillside, some three-quarters of a mile back from the water-front. Here there is a working face of 50 to 75 feet of white chalk, said to be 98 per cent. pure carbonate of lime. It is quite soft, readily breaking in the fingers, and readily disintegrating in water in the wash mills. Its only drawback is the flints, which occur in regular beds, some 5 or 6 feet apart, and making clearly defined outcrops across the working face of the quarry.

The process of mixing the raw material is the semi-dry, or Gorham, method. In this process the clay and chalk are thrown into the wash mill and mixed in a rather thick slurry containing but 40 per cent. of water. On passing from the wash mill, the slurry is ground wet between buhrstones, and then goes directly to the drying chambers of kilns of the Johnson type. The Johnson kiln, it will be remembered, is simply an intermittent kiln having a long drying chamber (or chambers) between the kiln and the chimney. The wet slurry is thus dried by the products of combustion of one charge, and the kiln is then recharged by simply taking up the dried slurry in the chamber and placing it in the kiln. It is evident that a process so simple and so direct could only be carried out with very pure and uniform raw materials. The fuel used is coke from the London gas works.

The balance of the works are much the same as at all other cement manufactories. The crushing and grinding machinery for the clinker, the stockhouse and loading and shipping departments, differ only in details at different plants.

Two things of notable excellence about the plant are the power house and the cooper shop. The engines are compound-condensing engines of the Corliss type, with rope transmission directly from the flywheel. This rope transmission is apparently held in high esteem in Europe, the writer having found it in all the cement plants he has visited. Usually the ropes are hemp and $1\frac{3}{4}$ to 2 inches in diameter. At Grays they are of special long-fiber cotton. There are about ten or twelve strands leading from the flywheel to the pulley on the main shaft of the mill,

and they appear to be in first-class condition after a service of eleven years. They transmit 300 horse-power.

The cooper shop has a full complement of tools for turning out barrels rapidly. One novel feature is the printing of the brand and label directly on the barrel heads. This is done in two overlays on each head and is evidently much better than paper labels pasted on, which may or may not stay—often the latter.

The Francis Works at Cliffe.

The Francis cement is quite an old brand, having been well known in America for twenty years. It has a prominent place in a long series of experiments reported by Mr. W. W. Maclay, M. Am. Soc. C. E., in a paper read before the Society in 1878.

The writer had the pleasure of visiting the works in company with the resident director, Mr. Vitale de Michele, M. Inst. C. E. They are situated on the south side of the Thames, in Kent, some 30 miles from London. They are three plants, one located directly in the chalk quarry, the other directly on the river front, a mile away, and a third between these two points.

The chalk is all quarried in the first plant, while the unloading of the clay (from the Medway) and the shipping are done at the second. The raw materials are precisely the same as at Grays—white chalk, Medway clay and London gas coke. The kilns are of the same general type, and the only difference in process is that at Cliffe the raw materials are mixed with more water in the wash mills instead of by the Gorham process of thick slurry and wet grinding. The power plant here is also excellent. The works in the chalk quarry present a most picturesque appearance, surrounded by the high white walls of chalk. Indeed, the blacksmith shops, stables and other minor offices are in excavations or caves directly in the chalk cliff, presenting a unique appearance inside and out.

These two works, as described above, fairly represent the English cement industry as it exists to-day. Pure raw materials, simple direct processes, and the absence of the Continental bureau of "Controle," are its characteristics. The natural advantages possessed by English manufacturers on the Thames are evidently very great, the location and shipping facilities, all things considered, perhaps unsurpassed anywhere in the world. What these plants could do if remodeled on lines of the best modern practice is evidently now the question for English

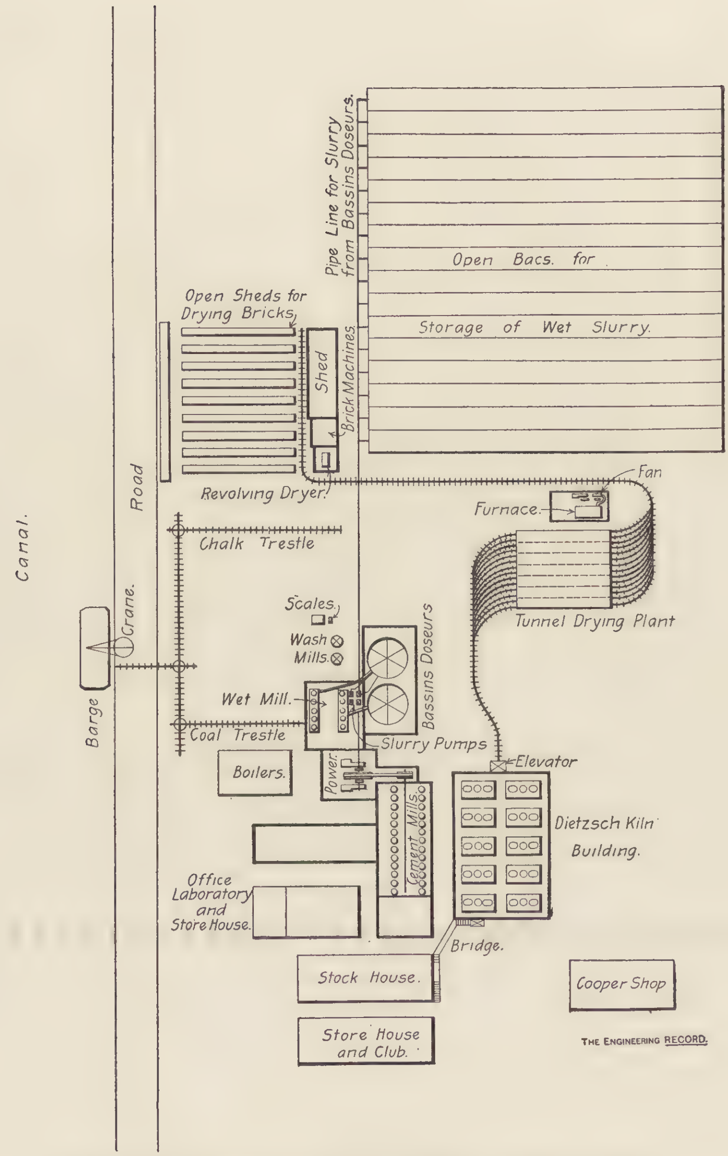


Figure 127.—Plan of the North Works at Beerse, Belgium.

manufacturers to consider. American manufacturers would jump at such a chance without a moment's hesitation.

The North Works at Beerse, Belgium.

In Belgium there are two distinct Portland cement industries. These are known respectively as the artificial and the natural Portland cements. Each has a trade association, but the two associations have nothing in common. The artificial Portland cements are made by the standard processes of Germany and France, and there are four manufactories, viz., North's Condor Cement Works, at Beerse; Société Anonyme de Niel-on-Ruppel; Dufossey & Henry, at Cronfestu; Levie Frères, at Cronfestu.

The latest of these manufactories is North's Works, at Beerse. The largest is Niel-on-Ruppel. North's Works have been built within the last ten years, the capital being chiefly supplied by the late Colonel North, the "Nitrate King," and the works being built on the plans and under the general supervision of Dr. Wilhelm Michaelis of Berlin. It is interesting to note, however, that the initiative in building the plant came from an American, Mr. William Schmole, formerly of Philadelphia. Mr. Schmole built the works in association with Col. Alexis Mols of Antwerp, the present director of the works, and the business was originally conducted under the name of Schmole & Company.

Having abundant capital, the plant was intended to represent the latest European practice, and is, therefore, very interesting to see. This privilege the writer was fortunate enough to secure through the good offices of the American agent of the firm, and spent Saturday, February 6, 1897, at Beerse, where a party of five gentlemen enjoyed the hospitality of the director, Col. Mols, and saw the plant under his guidance. The general arrangement of the plant is shown in Figure 127.

The first thing which strikes the visitor is the fact that the works are built at the clay deposits instead of the chalk, as is usual. The reasons which appear to have dictated this management are, first, proximity to Antwerp, and, second, the establishment of a very large brick works at Beerse by the cement company, which it operates in conjunction with the cement plant. The first 10 or 15 feet of the clay deposit makes admirable bricks, but it is not quite up to the required standard for cement purposes. All the material taken out of the clay bank is thus profitably utilized, and the two industries are conducted side

by side by the same staff. This clay is dark blue in color and very plastic, and the chalk which comes from Visé is very similar in color and analysis to the English chalk deposits.

In handling the raw materials the Continental bureau of "Controle" is in entire authority. At the side of the wash mills are the scales, and by the scales a telephone to the laboratory. Hour by hour, if necessary, the proportions of the materials going into the wash mill are modified by telephone orders from the bureau. The method of working the raw materials is, as indicated above, by the humid way, and this method is here seen in its fullest development. It consists of five distinct processes, as follows: First, the weighing of the raw materials. Second, the mixing of the raw materials in the wash mills, where 60 or 80 per cent. of water is added. Third, from the wash mills the slurry goes to millstones and is ground wet. Fourth, from the mills the slurry runs by gravity to the *bassins de dosage.* These are large basins in which the slurry is stirred by arbors similar to those in the wash mills. From these basins samples are taken to the laboratory at regular intervals by orders to the scalesman until the dosage is quite correct. The stream of slurry from the mills is then turned into another *bassin de dosage.* Fifth, from the *bassins de dosage* the slurry is pumped through a pipe line to the *bassins de repos,* or *bacs,* which cover several acres in extent. Here are stored usually normal cement slurry enough for several months' supply, and here a large part of the water is gotten rid of by evaporation and decantation.

The *bassins de dosage* were first introduced by French manufacturers at Boulogne, and it is probable they originated with Candlot, the well-known French authority. In his book, Mr. Candlot alludes to these basins as peculiar to the Boulogne plant, where it is well known he was long the chief of the bureau of "Controle."

In the summer, and most of the spring and fall, atmospheric influences are sufficient at Beerse to dry the slurry in the *bacs* for making bricks, and to dry the bricks, when placed in long lines of drying sheds, for the kilns. In winter, however, this cannot be done, and it will be interesting to the readers of The Engineering Record to learn that the latest addition to the works is an American drying plant, the Cummer dryer, made in Cleveland, O. This firm makes two forms of dryers, one a revolving dryer for the raw materials, and the other a tunnel dryer

for bricks. They have put in both at North's. The revolving dryer is not yet fully installed, but the tunnel dryer is giving excellent results.

The burning of the clinker is done entirely in Dietzsch kilns, and the grinding is done by millstones. All the mills are ventilated by suction from fans and there is very little dust. Large silos hold the ground cement. There is a cooper shop, a building for storing barrels, and another for storing cement in barrels.

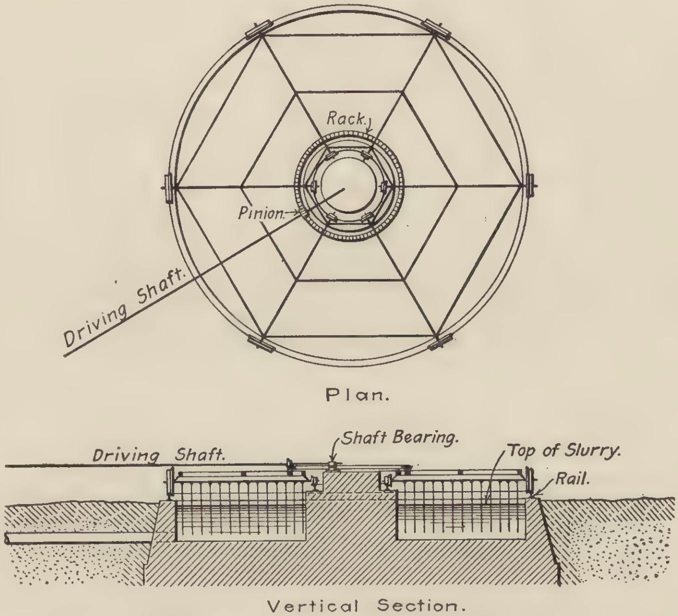


Figure 128.—Bassins Doseurs, Condor Works, Beerse.

Then there is a co-operative store and club house for employees. All the buildings, except the brick works and drying sheds, are of red brick, giving the plant a substantial appearance.

The product of the works at Beerse is 300,000 to 400,000 barrels, of which 25 per cent. goes to America.

Cement Sewer Pipe and Building Ornaments.

An interesting development of cement work in Belgium is the workshop of Blaton-Aubert, in Brussels. This firm does contracting for public works and manufactures cement sewer pipe,

both round and egg-shaped sections. The latter are made in two parts, a bottom and a cover, as shown in the accompanying cut, Figure 129. The feature of their business which is especially interesting, however, is the manufacture of molded work in Portland cement mortar. They make vases, busts, statues and large groups in this way, of many designs and of handsome workmanship. In fact, they reproduce in cement all the work of this kind which is seen in plaster of paris or terra cotta, with the great advantage that the product will stand exposure to the weather indefinitely, improving rather than deteriorating with age. The molds used are of plaster of paris, each large section made of hundreds of small sections dovetailed together so they can readily be taken apart one piece at a time. The product seems to be much appreciated, and in demand for galleries, gardens and parks.

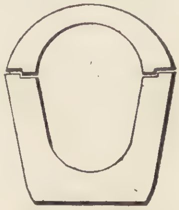


Figure 129.

CHAPTER XXII.—PLANTS IN GERMANY.

By Frederick H. Lewis, M. Am. Soc. C. E.

The Hamburg Cement District.

The first plant for manufacturing Portland cement was built on the Thames, in England, in 1825, by Apsdin, one year after the new product had been patented. But it was not until 1852 that the first German manufactory was begun. This was the Zulchow Works, at Stettin, built by Bleibtreu. To-day there are more than 100 manufactories of Portland cement in Germany, with an annual output considerably exceeding that of any other country, and with a high reputation for the general excellence of the product.

For purposes of comparison of English and German methods of manufacture, the works in the vicinity of Hamburg are especially interesting, because the raw materials are quite the same there as in England. That is, we have in both places the soft chalk of the North Sea coasts, readily disintegrating in water, and soft, plastic clay of quite similar composition. Of these German plants the writer had the pleasure of visiting three, the Alsen and the Laegerdorfer plants on the north side of the Elbe River, at Laegerdorf, and the Hemmoor plant on the south side of the Elbe, at Hemmoor.

The Alsen Plant.

By common consent the largest plant in Germany is the Alsen Works, near Hamburg, with an annual output variously estimated at from 700,000 to 1,000,000 barrels, quite a considerable percentage going regularly to the American market. The works were built by Alsen & Son, and the business is said to be still a close corporation owned by the Alsens. Mr. Carl Krichauf is the managing director, and it was through his courtesy that the writer enjoyed an opportunity of seeing their plants. They have three works, which are operated practically as one. The plant at Itzehoe is situated at the clay deposit, while the two plants at Laegerdorf are built alongside the chalk quarries. Itzehoe is to the north of the Elbe River and about 45 miles from Ham-

burg, on the West Coast Railroad to Northern Germany and Denmark. Laegerdorf is four miles from Itzehoe, on a canal leading to the railway and the river. The Alsens, however, operate a narrow-gauge railway between the two points, carrying chalk and clinker to the Itzehoe plant and clay and coal to the Laegerdorfer plants. As all the clinker is ground and barreled at Itzehoe, and there are two works at the chalk and one at the clay, the traffic on the railroad is about equal in amount in each direction, and the plant evidently designed for economical operation. There is a fine highway between the two towns, level for the most part, but skirting the wooded hillside of a large estate. Hills are very rare in Northern Germany, where most of the country is as flat as a Dakota prairie, and this road along the hillside is unusually attractive.

The raw materials of the Alsen properties are both apparently of excellent quality, the chalk, in particular, being of a fine white color in all parts of the two large quarries. Mr. Wolf, the chief of Bureau of Controle, is indeed quite enthusiastic over the quality of his raw materials and of the slurry he gets from them.

The mixture is by the humid way—the wash mill and the settling basin. The opinion seems to be universal in North Germany that the wet process is the only one to be considered for chalk and clay. Indeed, some manufacturers claim that better results can always be obtained by the wet process, whatever the raw materials. This view does not, however, prevail in South Germany, where the dry process is quite generally preferred. Certainly, however, remarkable results are obtained by the wet process considering the simplicity of the means employed. Practically the mixture is final at the wash mill. That is, there is no mixing done in the settling basins and there is no agitation of the material in them except by the stream of slurry pouring in. Yet the limit of variation allowed in regular calcimeter tests by the Bureau of Controle is declared to be 0.5 per cent. With materials which disintegrate in water as readily as chalk and clay, the settling basin seems to be all that is required to secure homogeneous slurry.

The Alsens ball the slurry (instead of making bricks of it), dry it in tunnel dryers and burn it in continuous kilns. Some of these are continuous kilns of the well-known Dietzsch pattern (or "two-storied kiln"), but most of them are of the Ger-

man style of high kiln or *schachtofen,* originally intermittent kilns, but remodeled so as to work continuously. This they are said to do very satisfactorily, both in respect to output and economy of fuel. The Bureau of Controle has a well-equipped laboratory and there are smaller laboratories for physical tests at each plant.

At the Alsen quarries all the material is handled by railway, and this service, in connection with the line between Itzehoe and Laegerdorf, demands quite a considerable equipment in motive power and rolling stock, and in facilities for repair, etc.

The firm owns, too, a large tract of land not required for manufacturing, and this is devoted to farming and stock raising. One of the principal buildings of the village street is the Alsen cow barn for housing the milch cows and their calves in winter. Built of brick and iron throughout, and fitted with many ingenious contrivances, it affords stable room for some 60 head of cows, beside separate quarters for 20 or 30 calves, rooms for milk storage, creamery, etc. The firm has besides in the village a workingmen's boarding house and a workingmen's club house, both of ample size and well equipped and maintained, and it would appear that the laboring class might find many worse places to live in than Laegerdorf.

The Laegerdorf Plant.

This is a comparatively new plant, with an annual output at present of 200,000 barrels. It is on the canal, one-half mile above the village. The raw materials are like those at the Alsens', the chalk being, in fact, quite the same; the mixture is also the same, except that there are small settling *bacs* provided between the wash mill and the *bassins de repos,* evidently for the purpose of eliminating any sand which may be present.

The settling basins cover quite a large area on each side of the canal. These great areas of *bassins de repos* are indeed a feature of the Hamburg plants. The slurry dries so slowly in them in winter that it is necessary to provide large storage capacity. The works have a complete brick plant with a system of tunnel dryers. The kilns are six in number, double Dietzsch continuous kilns, and the grinding is by French buhrstones. The stock house is across the canal from the mills, and a novel feature is a belt conveyor taking the ground cement across a bridge turning at right angles, and delivering it in the stock

house, some 200 feet away. Another phase of American enterprise is met at the Laegerdorfer works, this time in the form of a set of American drying kilns for drying barrel staves.

The Hemmoor Plant.

This plant is quite large, producing 500,000 to 600,000 barrels per year, and has evidently been in operation a number of years. It is situated 50 miles from Hamburg, on the railroad to Cuxhaven. The method of manufacture is practically identical with that of the Alsen works, and the kilns are alike in the two plants—Dietzsch kilns and high kilns remodeled to work continuously. There are two features worth special notice—one, the use of the American Griffin mill for grinding, and the other the fine laboratories of the works, both for research and for "Controle." The director of the works is Dr. Pruessing, whose name became familiar to American readers in connection with a report made a year or two ago on accelerated tests of cement, and the doctor has notably good laboratories, well equipped for every kind of test that has ever been proposed for cement.

A new form of accelerated test is here used, designed by Dr. Pruessing, and which is as follows: To 100 grams of neat cement, 7 grams of water are added and well mixed; the very dry mortar thus made is then placed in a matrix 8 centimeters in diameter and subjected to a pressure of 2,500 kilograms. The cake is at once removed, and after hardening for 24 hours in air is subjected to the hot bath at a temperature of 70 degrees to 80 degrees Centigrade. It is claimed that this test is more severe than any form of boiling test yet devised, and as such it may commend itself in America to those who are looking for a test of this description. It is only fair, however, to add that the apparatus is rather expensive.

From these brief descriptions of the Hamburg plants it will become clear to the readers of The Engineering Record that the German practice of dealing with chalk and clay differs from the English in two points, viz.: 1. The use of *bassins de repos*. 2. The operations of the Bureau of Controle. Any other differences are merely those of detail.

The German Marl Cements; The Hanover Works at Misburg.

There are an interesting group of German Portland cement works employing "mergel" (English, marl; French, marne) as the principal raw material. "Mergel" is a natural mixture of

clay and carbonate of lime and is generally fossiliferous, containing shells and frequently other fossils. The writer enjoyed an opportunity of visiting two of these works—the Hanover plant at Misburg, and Heyn Brothers plant at Lueneburg. In the former the method of procedure is by the dry way, and as this method has not yet appeared in this correspondence, the Hanover works will be described first.

The Hanover Portland Cement Works are located at Misburg, a few miles east of the city of Hanover, on the main line of railroad between Cologne, on the Rhine, and the capital at Berlin. They have also direct rail communication northward with the ports of Bremen and Hamburg. The works are under the joint resident direction of Dr. Erdmenger and Mr. Kuhlemann, both well-known and prominent men in the German Association. They are shown in plan in Figure 130.

The natural advantages of the plant are at once apparent. It is built directly at the railroad, with siding facilities like any other manufactory, while just below the surface of the ground is found a marl deposit of some 40 odd feet in depth over the entire property. Immediately below the marl is found the clay. Both raw materials thus occur directly in situ and are cheaply and expeditiously handled by an inclined plane descending from the rear of the mill.

The marl is grayish white in color, as soft and apparently as easy to dilute with water as chalk. It is a natural mixture of carbonate of lime with clay, quite free from other impurities. The proportion of clay in the marl varies from place to place over the face of the quarry, but is generally within 10 per cent. of normal proportions for cement. At the time the writer was there, the marl was exactly normal, being used just as it came from the quarry. The clay is really another bed of marl in which the clay predominates instead of the carbonate of lime.

Under these conditions the ordinary work of the Bureau of Controle is very simple. Nature has already mixed each of the raw materials with a large proportion of the other; to strike a close average of normal proportions and to further complete the mixture is evidently a matter of simple routine. In the operations of the Bureau of Controle the raw materials are analyzed regularly as they come from the working face of the quarry, and the mixing proportions are slated at the scales from day to day, or even from hour to hour, if necessary. A second deter-

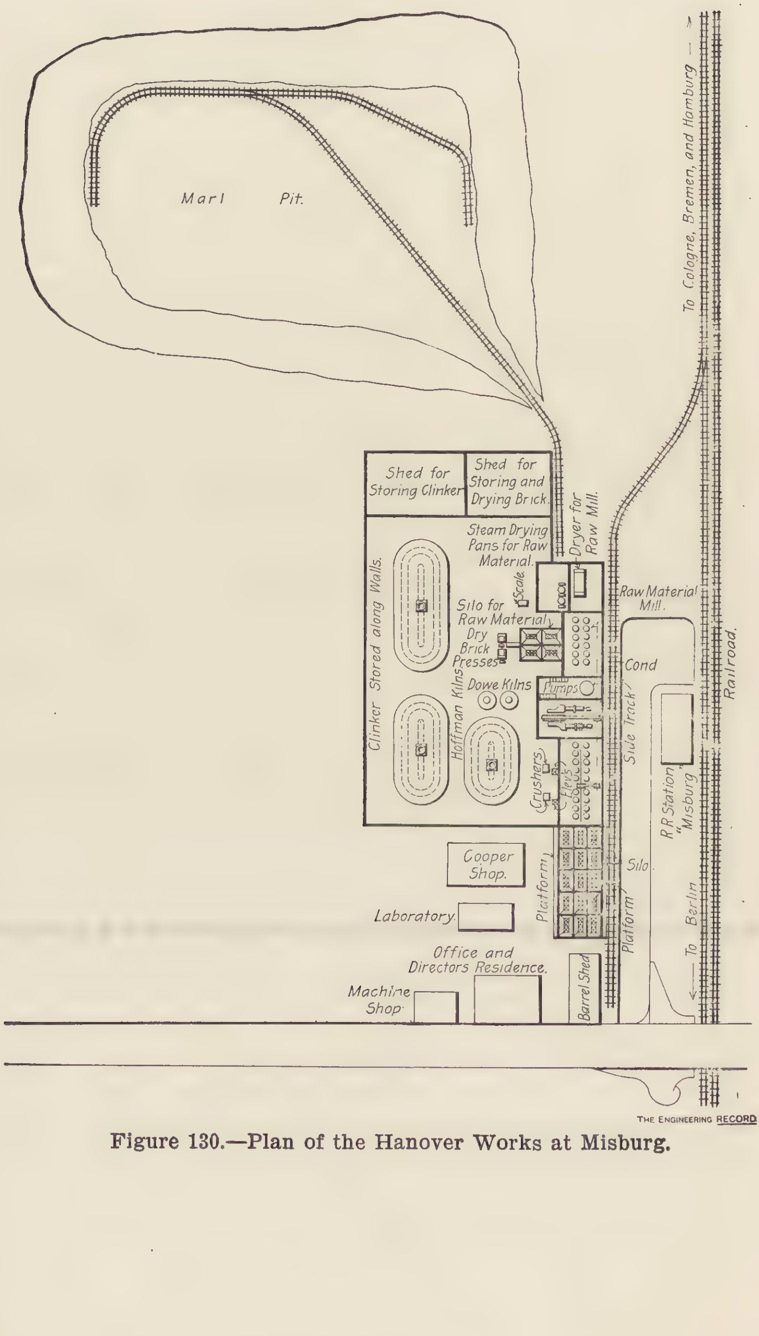


Figure 130.—Plan of the Hanover Works at Misburg.

mination is made after the material has been ground dry and has passed into the silos, and lastly, a third determination is made of the bricks prepared for burning. These analyses proceed in regular course under a system of routine adopted by Dr. Erdmenger, which has proved so efficient that the doctor declares the analyses of bricks are "always right" within a limit of one-half of one per cent.

As the raw materials come from the quarry they contain something like 11 per cent. of water, which must be eliminated before the material can be ground. It was formerly the custom to bring the raw material from the quarry and spread it on steam drying pans placed upon the ground. To dry the material in this way, however, required a large area covered with drying pans and a great deal of manual labor in loading and unloading. Besides, it evidently was not economical in fuel. The company had therefore modified the plant just prior to the writer's visit by the installation of a Cummer revolving dryer for drying the raw materials. This is the American dryer mentioned previously in these descriptions, and, as installed at the Hanover works, is giving very satisfactory results. The method of working with the new dryer is to bring the raw materials directly from the quarry to the scales and thence to an edge-runner mill. This edge-runner mill consists simply of a pair of large rolls fitted loosely on the same axle and running on a revolving plate below. The outer third of this revolving plate is perforated with holes, so that all material up to the size of a pea shall pass through. From the edge-runner mill the material is carried by elevator directly to the Cummer dryer, through which it passes continuously at the rate of 15 tons an hour. Thence it is carried by elevator and transmission apparatus to the mill, where it is ground, bolted and passes to the silos for raw material. With such soft raw materials and materials which are already approximately normal in their natural state, it is evident that the edge-runner and the millstones will complete a very intimate mixture. A curious evidence, however, of the purpose to insure a homogeneous mixture by every means available is seen in the long lines of worms which conduct the pulverized material from the mill to the silos. These worms, instead of being continuous, are made of a series of knives bolted at intervals to a central shaft. When Dr. Erdmenger was asked why this discontinuous worm was used, he said it was for mix-

ing; at every blade a part of the cement was pushed on and a part remained, and thus the mixing went on continuously with the transfer of the material. This same style of worm is used in forwarding the material to the brick machine and also in forwarding the cement to the cement silos.

A German cement silo is, as near as may be, built on the model of an American grain elevator. That is, it consists of a series of bins in which the dry material is deposited by elevators and from which it is drawn below by spouts. An illustration of

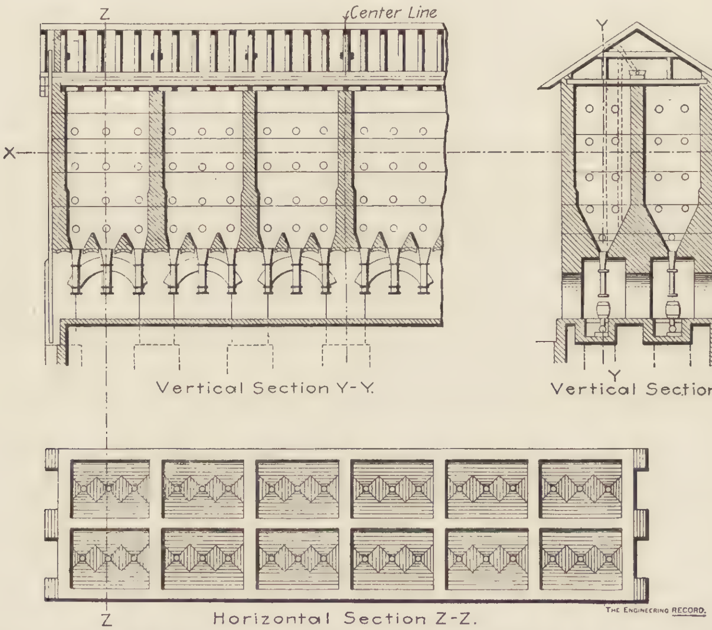


Figure 131.—German Cement Silo.

the type of construction used is given in Figure 131. The kilns at the Hanover plant are Hoffman kilns, or so-called "ring ovens," which require the raw materials to be delivered in the shape of bricks. But as the method of working is entirely by the dry way, and as any moisture used to mold the bricks must be subsequently driven out either by exposure to the air or by the heat of the furnace, it is desirable to make the bricks with as little water as possible. This is done by running the

ground raw material continuously through a sheet-metal trough and adding a small continuous stream of water intended to be from 5 per cent. to 7 per cent. Thence the material is passed to the brick machine. This machine is not a pug mill, such as is used in making bricks in wet processes, but a press known to the trade as a dry press. In this press the raw material falls through hoppers and is automatically delivered to the molds. The heavy presses are raised by cams and strike each brick three sharp blows, delivering it warm, firm and nearly dry. The bricks are stacked in great piles in sheds, so that they lose most of the water they contain before being placed in the kilns.

The Hoffman kiln or "ring oven" in use in the Hanover works was originally used in Germany in making bricks. It consists of a continuous gallery of an elliptical shape built around a central chimney. There are usually 15 or 20 compartments, with as many entrances from the outside and as many ports leading to the chimney. In practical working in a kiln of 20 compartments, there are, say, six which are filled with burnt clinker, still warm, two which are in process of burning, six which are filled with bricks not yet burned, and in the remainder charging and discharging is in progress. The connection with the chimney is by the port in the last chamber filled with bricks, and the draft is through the open door of the compartment on the other side which is being discharged of clinker. All intermediate openings, both to the chimney and to the outside, are sealed and a heavy paper partition is pasted across the gallery (and against the bricks) just beyond the open chimney port. Thus the air is heated by passing through the hot clinker in six chambers and arrives at a high temperature in the combustion chamber. Similarly the products of combustion pass through several chambers filled with bricks which are thus heated to a high temperature before burning actually begins. These kilns are widely used in Germany, and evidently are economical of fuel, but expensive in manual labor. In the best practice with Hoffman kilns about one ton of coal is required to produce 6½ tons of clinker, a performance which is very much better than anything which has ever been done with discontinuous kilns. At the Hanover works they have three of these kilns, with a capacity of 70,000, 80,000 and 100,000 barrels per annum, respectively, and they also have three of the old discontinuous dome kilns, so that their annual capacity is about

300,000 barrels. The grinding of the clinker is done entirely by French millstones and the fineness regulated by bolting through sieves. The cement is stored in silos.

The power plant of the works, like nearly all European power plants, is of a high standard of excellence. For grinding the raw material there is a compound Corliss engine of 250 horse-power, and for grinding the clinker a similar engine of 900 horse-power, and in both engines the power is taken directly from the flywheel by rope transmission. The works have a fair laboratory service for control, and a laboratory for research which is only remarkable for the high character of the work which Dr. Erdmenger turns out of it.

Heyn Brothers' Plant at Lueneburg.

This plant is situated in the ancient town of Lueneburg, about an hour's ride by express train to the south from Hamburg, and having both rail and canal facilities. The marl is practically the same as at Hanover. The clay is more nearly a pure clay. The method of work, however, is entirely by the wet process, employing the wash mill, settling basin and brick making with tunnel dryers for drying the bricks. The plant is in excellent order, showing many details of mechanical excellence. The marl quarry is perhaps a quarter of a mile from the wash mill, on the other side of the highway, and the raw materials are carried by wire cableway across this space with rapidity and economy. Similarly in the brick-making and brick-drying plant, the carriages are run on a system of overhead runways exactly similar to those in use in a Chicago packing house. All the buckets, however, are provided with grips, and in leaving the brick works for the top of the Dietzsch kilns they are gripped to a cable and carried forward and upward by it. On the upper stories of the kilns the buckets are again carried by a system of runways. The whole scheme is expeditious and economical. The firm employs Dietzsch kilns exclusively to burn its clinker, and is preparing to use the American Griffin mills exclusively for grinding. They have had two of these mills in use for some time, but are now putting in three more which will grind the entire output of the works. It is evident that the advantages of the Griffin mills must have proved considerable at Lueneburg, since they will displace a very excellent plant of French millstones. Except, therefore, for the raw

material employed, which is chiefly marl instead of chalk, the Lueneburg plant might be classified with the Hamburg plants.

There are a number of other works in Central Germany employing "mergel" as the raw material, the largest of them being the Germania Works at Misburg and Lehrte.

German Cements from Hard Raw Materials—The Dyckerhoff Works.

No brand of imported cement is better known in America than the Dyckerhoff cement, and no manufacturer has maintained a more constant interest in the technical side of cement-making or taken a more prominent part in such questions before the German Association than Mr. Rudolph Dyckerhoff. The Dyckerhoff plant is located directly upon the River Rhine, at Amoeneburg, a few miles below the city of Maintz. The river is an important factor in the plant. The coal comes by barges, the clay also is brought from the Main, the tributary stream a few miles away, and the greater part of the product of the works is shipped by the river. From the river side there is a cable tramway leading under the highway through the works. The plant itself covers a large area, and the process of dealing with the raw materials is quite unique. Back a mile or two from the river-front is the limestone quarry, and this quarry contains in different beds three different grades of stone. These are: 1, a hard limestone; 2, a soft limestone, and 3, a soft marl. By the process employed all three are utilized, and, as will be seen below, they are not only utilized, but this diversity in the character of the rock becomes a positive advantage. The hard and soft limestones are substantially the same in composition and do not vary much, being approximately 80 per cent. carbonate of lime. The marl is more irregular in composition.

Thus, with the clay, the plant employs four different raw materials. In order to do this two distinct plants are employed, one dealing with raw material entirely by the dry way, and the other dealing with it entirely by the humid way. The raw material prepared dry is the hard limestone, with such suitable additions of soft marl and clay as may be required to produce normal composition for cement. These three materials are first dried over drying furnaces, then pass through crushing machinery and are ground and incorporated together in millstones. While this process is going on at one plant, a wholly different

preparation by the humid way takes place at the other. In this the soft limestone, marl and clay are brought together, in proportions fixed by the Bureau of Controle, in wash mills. Thence the stream of slurry passes to millstones and is ground wet, and from these mills it is pumped to long lines of troughs mounted on trestles to the settling basins, where it dries by evaporation and decantation, as in the regular wet or humid process. It is probable that the soft limestone and marl of the Dyckerhoff works is less easily diluted with water than the materials found further north in Germany, and that this makes the wet grinding desirable. The wash mills, too, instead of being provided with harrows on arbors, as in the mills in Northern Germany, are provided with edge-runner stones which crush as well as mix the raw materials.

The two processes, wet and dry, go on side by side at the rear of the works, the part most remote from the river. Lying immediately in front is a large area devoted to *bassins de repos,* and traversing this are the overhead runways for conveying the slurry to the basins, an overhead cableway for conveying the dry, raw material to the brick plant, and tramways on the ground for conveying the thick slurry from the *bassins de repos* to the same point. At the brick plant the wet and dry materials are brought together, and the first operation is to mix the wet slurry with the dry powder in any required proportion to give the material the proper consistency for the brick machines. As both wet and dry materials are normal in composition (or intended to be so) the proportions in which they are mixed is immaterial, and may be varied at will by the foreman, whose only care is to produce the consistency required. It is here that the utilization of the hard limestone by the dry process becomes a distinct advantage in working. The slurry can be used much wetter than if only wet material were used. This is an advantage at all times, but especially so in winter, when the drying of the slurry is always slow, and often a serious difficulty. The two materials are mixed in *malaxeurs,* and from them are carried upward by an inclined belt conveyor to the top of the brick-making machines. The whole process is well considered and carefully worked out to suit the conditions.

At the Dyckerhoff plant, Hoffman kilns are employed exclusively. The works have seven of these kilns, producing yearly

about 700,000 barrels of cement. The standard kiln of the works has 20 compartments, and a round of the compartments is made twice a month. Each compartment is reckoned to produce from 250 to 300 barrels of cement. All the kilns are arranged with drying chambers, in which the bricks are dried by the waste heat. These chambers are built around the upper or firing deck of the kilns, and have large ventilating hoods in the roofs above. A good many bricks are also dried directly on top of the kiln. There are two special grinding plants for clinker, both using French millstones exclusively and both having fine power plants. One mill has a compound Corliss engine and the other a new 1,000-horse-power triple-expansion engine, probably the handsomest piece of machinery in any cement works in Europe.

Dr. Schumann is at the head of the Bureau of Controle of the Dyckerhoff works, and has an excellent laboratory, which does not only this work, but a large amount of the experimental work in which Mr. Dyckerhoff and Dr. Schumann are engaged. For more exact analyses the firm avails itself of the laboratory of Dr. Fresenius of Wiesbaden.

The Mannheimer Plants at Weisenau and Mannheim.

The Mannheimer Portland Cement Company is one of the oldest in Germany, two others only, it is believed, antedating it, and a considerable part of its product has for many years found a market in America, where it has held an excellent reputation. The original works were located at Mannheim, but a newer and larger plant has now been built at Weisenau, just outside the city of Maintz. The Weisenau plant is thus evidently the more interesting of the two, but as the writer did not know this he went to Mannheim and did not see the Weisenau plant. As described by Mr. Merz, the director of the company, the raw materials at Weisenau are substantially the same in character and from the same geological formation as the Dyckerhoff works. The plant is on the opposite side of the Rhine from Dyckerhoff's and but a few miles distant. In working the raw materials also the process follows similar ideas, but differs considerably in details. At Weisenau the hard and soft limestone and the marl are all prepared by the dry way. The clay only is made into slurry, and the dry pulverized limestones and the clay slurry are incorporated by special machinery adapted for this purpose

and the paste made into bricks. This is evidently another adaptation of means to ends in dealing with these raw materials, and is an ingenious modification of the dry process. The plant at Weisenau uses both Dietzsch and Hoffman kilns, and produces 350,000 pounds of cement annually.

At the Mannheimer plant we find raw materials which are harder than any yet described. The limestone, which is 85 per cent. of the material employed, is all quite hard, and the clay is shaly or partially indurated. The method is wholly by the dry process. The material is all dried on open dryers set on the surface of the ground, and the materials are mixed, crushed and ground dry in millstones. The pulverized raw material is then made into bricks with a limited quantity of water, and the bricks are then dried for the kilns. It will thus be seen that the handling of the raw materials at Mannheim is not essentially different from the method pursued in the Lehigh Valley of Pennsylvania.

The Mannheimer has five Dietzsch kilns and one Hoffman kiln, and produces about 250,000 barrels of cement annually. A part of the grinding is done by millstones, but a more recent installation is the German "kugel" mill, a revolving cylinder with fluted sides, in which the clinker is ground by the impact of the steel balls. The product of this mill is bolted and the coarser particles are then reground in the new Danish ball mill. This is specially adapted to fine grinding and is simply a revolving cylinder loaded with flint balls which grind by abrasion and impact.

The Schifferdecker Works at Heidelberg.

The Schifferdecker works at Heidelberg were destroyed by fire some time ago, and are now in course of rebuilding. The writer had a cordial invitation from Mr. Schott, the director of the works, to visit the plant, but was unable to do so on account of other engagements. The plant is said to employ hard, raw materials exclusively, and a conception of the size of the new works may be arrived at from the fact that the firm has ordered 65 Griffin mills for grinding the raw material and clinker. The interest in these works would be chiefly in the details, since the general method of handling material by the dry way has already been described in this correspondence.

The readers of The Engineering Record will already have discovered from these letters that there is no "German" method

of making cement. The successful plants are those which most intelligently adapt means to ends and suit their plants to the raw materials and to the local conditions. This is a very old idea, often lost sight of, but is evidently the only basis on which successful manufacturing can be conducted either in Germany or in America.

The German Cement Kilns.

The kilns now most generally approved and most widely used in Germany, for the manufacture of Portland cement, are the Dietzsch and Hoffman kilns, both of which have been mentioned in this correspondence. They are both continuous kilns, but differ in this respect, that while in the Hoffman kiln the fire

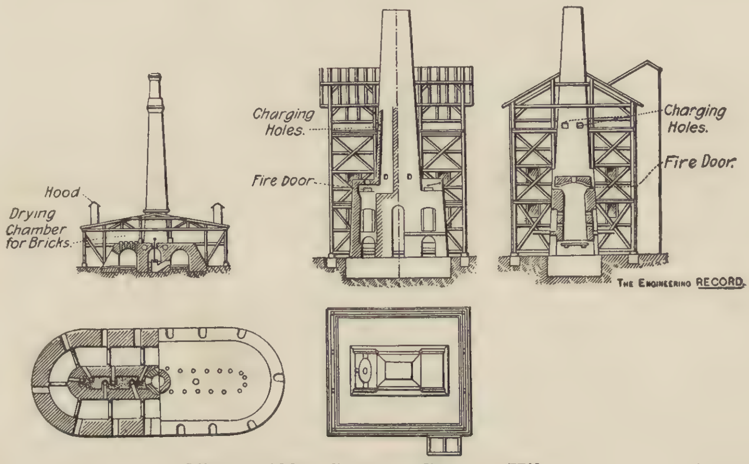


Figure 132.—German Cement Kilns.

passes from chamber to chamber and the material rests in place, in the Dietzsch kiln the combustion chamber is fixed and the material passes through the fire. The kilns are both also economical in fuel, and both accomplish this in substantially the same way; that is, they heat the draught of air by passing it through the burnt clinker before it reaches the combustion chamber, and they utilize the products of combustion to heat the raw material before it is subjected to the fire. In the Dietzsch kiln the furnace is vertical and in the Hoffman it is horizontal.

The general scheme of the Hoffman kiln was described in the letter on the Hanover Works, but this will be made clearer by Figure 132, which is taken from the recently published book of

Dr. Schoch of Berlin. The bricks are wheeled into the chambers at the ground level and piled by skilled workmen. The fuel is introduced from the top through the orifices in the roof. It is necessary to pile the bricks in quite a special manner, so that the gases may pass readily through the mass and to leave vertical spaces beneath the opening in the roof through which the fuel may descend to the bottom. The practice in this respect differs in different works as the result of experience, but the scheme will be readily understood from the illustration and description given.

The Dietzsch kiln is shown in detail at the right of the cut, taken from a bulletin of the French "Société d'Encouragement pour l'Industrie Nationale." The drawing is practically a working drawing of the Dietzsch kiln, or the "kiln with stories," as it is also called. This kiln was patented in 1884 and first used in 1886, since which time a large number of them have been built in Germany. The kiln is operated continuously by charging the dried slurry into the chimney through the door shown at the upper floor of the kiln building and by drawing the burnt clinker from the grate at the bottom. The peculiarity of the kiln is at the fire bridge, where there is a horizontal offset uniting the lower and upper parts of the stack. The part of the furnace just below the fire bridge, some 5 or 6 feet in depth, is the combustion chamber. The chimney above is the pre-heater for the raw material, and in the shaft below the combustion chamber the clinker is cooled.

In practical working the dried bricks or dried slurry are carried by elevator to the fifth story of the kiln building and are charged into the chimney. The chimney is kept filled with bricks to or near the level of the charging door, and at the bottom they fall across the fire bridge half way to the combustion chamber. At certain intervals throughout the day the burnt clinker is drawn from the bottom of the kiln and the entire mass above the fire bridge descends. This is then filled by drawing bricks from the chimney across the fire bridge to the combustion chamber and adding with them a proper quantity of fuel. The most trying labor at the kiln, therefore, is at the level of the fire bridge, which is the third story of the kiln building. Here the bricks must be carried across the fire bridge by manual labor employing long-handled iron bars through the fire doors, and the fire must be regularly maintained.

The fuel used is a powdered gas coal containing a large percentage of volatile matter, so that the flame from it passes over the fire bridge and up the chimney. The bricks in the chimney are thus gradually heated as they descend, until at the time they reach the fire bridge they are red hot and practically all the carbonic acid has been expelled. In the combustion chamber the bricks are clinkered, and in the shaft below the burnt clinker is cooled by the draught of air so that it reaches the grate at the bottom cold enough to handle. In the latest practice the Dietzsch kilns are operated under forced draught.

Just below the combustion chamber several doors are provided in the side of the kilns to observe the fire, so as to know whether it is proceeding properly. From these doors, and also from one in the top of the kiln, just over the combustion chamber, the fire can also be poked to prevent balling up of the clinker, or to detach masses clinging to the sides.

In the actual working of the kiln proper the Dietzsch kiln is more economical of fuel than the Hoffman, but since it is necessary to use thoroughly dried bricks in the Dietzsch kiln, requiring, generally, some artificial heat for drying, the total fuel consumption is probably not very different in the two kilns, showing a production in first-class practice of between six and seven tons of clinker per ton of fuel. In manual labor also there is probably not a very great difference in the working of the two, drying and calcining both considered, the advantage, if anything, being probably in favor of the Dietzsch kiln.

In fact the impression of the writer is that both in fuel and labor there is some advantage in favor of the Dietzsch kiln, while for yield on capital invested in the plant the Hoffman kiln makes the better showing.

CHAPTER XXIII.—PLANTS IN FRANCE.

By Frederick H. Lewis, M. Am. Soc. C. E.

Portland Cement in France.

French Portland cements are not exported to America, and the character of the French works and their products are very little known with us. Yet in several important respects French practice in making and in using cement is extremely interesting. Nowhere is the industry better organized, or does its organization more strictly follow the lines of scientific method, and nowhere does practice represent greater experience. This may surprise those who know the comparatively small output of cement in France; not more, perhaps, than one-fifth of the German product. But it is so, and an explanation is found in well-known facts, the force of which will be recognized once they are cited.

One of these is the early precedence which French science took, and has since held, in dealing with the phenomena of hydraulic binding media. A dozen years before the Portland cement process was discovered, Collet-Descotils, of the "Ecôle des Mines," at Paris, demonstrated that the silica in lime rocks became soluble when the limestone was brought to red heat, and he argued from this that the silica combined with the lime during calcination to give it hydraulic properties. This is the fundamental fact of all cement making. Vicat's long series of investigations dates from the same early period, and his books are classics of cement literature. Many names will be recalled since these, and among them the present group of men who are to-day treating this subject with such marked ability in France.

The second reason which gives the French industry and French practice special interest is the fact that the manufacture of cement in France is virtually controlled by the engineers of the Ponts et Chaussées, the celebrated corps which, for 175 years, has been charged with the public works of France. Just what this means will be better appreciated by a comparison. Thus, with us the national public works do not carry much prestige;

are, in fact, of quite minor importance, often less in annual expenditure than the public works of some of the greater cities. Yet it will be readily admitted that if a standard specification for cement were adopted by the U. S. Engineer Corps, it would have great weight with manufacturers and with consumers. Now, in France, the administration of national public works is charged with the supervision of "all works of a public character or necessity, whether undertaken by the State, the department, committees, public boards or syndical associations," and whether paid for at the government's expense or not. These works comprise "the construction and maintenance of the public roads and bridges, the construction and maintenance of commercial ports, dykes, sea-coast works—such as dredging, etc.—canals and works for maritime purposes and navigation of the interior, the establishing and building of lighthouses, beacons and buoys, the improvement and maintenance of the navigation of rivers and tributaries, towpaths, jetties, piers, works for shore protection to river banks—drainage and reclamation of lands, construction and maintenance of railroads, etc." Military works, city works proper and private enterprises without public interest are excepted, but practically all the rest comes under the supervision of the Engineers of the Ponts et Chaussées. The specifications of this great department of public works become, therefore, of prime importance to manufacturers, and of the greatest interest to anyone who would make himself familiar with French cement affairs. The scope which these specifications have will be apparent from the following extract from Article 2 of the specifications of the Maritime Service: "The Administration reserves to itself the exercise of control, under conditions which shall be determined by it, of the fabrication, the preservation in store at the works, and the shipping of cement which may be furnished in executing the present contract. For this purpose the engineer or his delegate shall have access at all times to the parts of the works engaged on this product, and he shall be able, 1, to make all dispositions that he shall judge necessary to assure himself of the composition of the crude slurry employed for the product intended for the Administration; 2, to control the sorting of clinker for calcination; 3, to follow the cement submitted from the sorting of the clinker to the special warehouse where it will be stored for shipping; 4, to control the special lead seal-

ing of sacks leaving the storehouse and the shipping of the cement; 5, to place special men remaining permanently at the works for the above purpose."

It will be seen from the above that the specifications contemplate an inspection service at the works, dealing with the manufacture from the raw materials to the shipping of the product, and just such a service is actually in force. The specifications of the Pont et Chaussées have been adopted by the Military Engineers and by the Colonial Administration, and the city of Paris has adopted quite similar requirements. In this way we find in French cement works a number of inspectors present, one representing, say, the maritime service of the Ponts et Chaussées, another the inland service for the same corps, another representing the city of Paris, and perhaps a fourth representing the military organization. The case is exactly the same as in an American steel works, where numerous inspectors are present representing purchasers. Thus the French works are brought into direct contact with the Engineer Corps, with the schools and with the best science.

The Works of Darsy, Lefebvre, Stenne and Lavocat at Neufchâtel.

These works were established in 1862 by Messrs. Darsy & Lefebvre, and are now under the direction of Mr. Lavocat, through whose courtesy the writer was permitted to see the plant. It is located at Neufchâtel, a quarter of an hour's ride by rail to the south of Boulogne, and is quite a large plant, having 15 Johnson kilns and six continuous kilns. The raw materials are marl and clay. The marl comes from a quarry two-thirds of a mile away and the clay from the valley beyond. The marl as quarried contains considerable clay, varying from 10 per cent. up to the full amount required for cement slurry (say 22 per cent.), and hence the amount of clay which it is necessary to add is small.

The thing which impresses one first in visiting a French cement plant is the extreme simplicity of the arrangements and the careful study of economy in manual labor. The conditions in France approach more nearly to our own in that respect than elsewhere in Europe. Labor is dear, and so we find Mr. Lavocat bringing his marl to the wash mills by rail in dump cars, using an electric trolley locomotive, just as in the latest practice in

America. One locomotive and a small crew thus does all the hauling of the marl. We also find that the analysis of the raw materials figure very little in French manufacturing. The clay and marl are mixed in the wash mills in proportions which are merely approximate. It is the *bassins de dosage* and not the wash mills which determine the proportions of the slurry. Mr. Lavocat has three wash mills, two of which are in use; from them the slurry overflows through fine metal sieves and runs with a gentle slope into one of the three *bassins de dosage.* On the other side of these *bassins doseurs* are two small wash mills, one using a marl of known composition and the other using pure clay. It is not until a *bassin de dosage* is full of slurry that the French chemist appears upon the scene. He then takes samples of the slurry and analyzes it, not for carbonic acid by volumetric determination, as is common in Germany, but for clay by gravimetric methods. At the Darsy works the limiting figures for clay are from 21 to 22 per cent., and any variation beyond these figures is corrected by adding pure clay or pure marl to the basin from the small wash mills described above. It may take one, two or three determinations to get the right mixture, but it is not until the mixture is normal that the slurry escapes from the *bassins de dosage,* and it is not until it is considered normal that the inspectors of the Ponts et Chaussées take their samples.

The laboratory of the Maritime Service of the Ponts et Chaussées is at Boulogne and is under the direction of Mr. Feret, the well-known engineer. Mr. Lavocat showed the writer a long series of check analyses made there on the slurry which the inspectors had sampled. The results and analyses made under the direction of Mr. Feret are available to the manufacturers of the cement, and it is apparent that while the supervision of the Ponts et Chaussées is close and rigid, the relations which it sustains to manufacturers are nevertheless cordial, the results obtained being always freeely available to a manufacturer for his information and guidance.

From the *bassins de dosage* the slurry runs by gravity to the drying chambers of the Johnson kilns. These kilns are exactly like those described in England; that is, they are discontinuous kilns, having long drying chambers between kilns and chimney in which the slurry is dried by the products of combustion.

The kilns, which are really French, and new to this correspondence, are the continuous kilns mentioned above. For the service of these kilns the slurry is run into settling basins, like those in Germany, where half the water is gotten rid of by evaporation and decantation. The balance of the water is eliminated in the drying chambers of the kilns, being brought there in cars by elevator. The lower drying chambers are laid with rails and there are turn-tables and switches, so that the cars reach all parts of the upper and lower drying chambers of these kilns. Now it will be apparent to your readers that a continuous kiln with drying chambers is a novelty. Nothing of the kind has been mentioned before in this correspondence, and this kiln is, in fact, an evolution of French practice. Imagine, then, a kiln of the Johnson type, made higher and narrower, and having two sets of chambers (upper and lower for each), instead of one leading from the kiln to the chimney. It is evident, then, that by valves or ports the products of combustion can then be made to pass at will either through one pair of chambers or the other, and the operation of the kiln can thus proceed continuously, regardless of the charging and discharging of the material from the drying chambers. The scheme is very simple, and the furnace itself is extremely simple in design. The slurry and the coal are charged into the kiln from the top through an opening arranged like the charging door of a blast furnace. At the Darsy works there is also a door in the side opposite to the drying chambers, through which the fire can be observed and clinker and coal added if desirable. These kilns produce about twice the product per day that can be obtained from a discontinuous Johnson kiln, and achieve considerable economy in fuel besides. The cost of manual labor is said to be about the same. The six continuous kilns at these works, as originally built, were Johnson kilns, and were remodeled by Mr. Lavocat into their present shape.

On the clinker floor at the bottom of the kilns the writer gets a view of what the Ponts et Chaussées requires in the way of sorting clinker. Heaped against the walls opposite certain furnaces are piles of clean, hard, black clinker, quite free from underburnt or dirt. It is the very choice and pick of the product. Mr. Lavocat explains that this is for the sea-water work, and is required by the inspectors of the Maritime Service, and

he admits, too, that it is quite right for sea-water work that all the underburnt clinker should be excluded. Referring to the specifications for the Maritime Service, we find that the cement is "required to be produced by the grinding of scorified clinker obtained by calcining to the softening point of an intimate mixture of carbonate of lime and clay, rigorously proportioned chemically and physically homogeneous in all its parts." The specifications further require that cements containing more than 1 per cent. of sulphuric acid, or sulphides in determinable proportions, will be refused, and that any cement will be declared suspected that has more than 4 per cent. of oxide of iron, or which will give a less value than 44 per cent. for the ratio of combined silica plus alumina to the lime. This demand of the French specifications for pure cement with a selection of the very best clinker may account for the remarkable success which the French engineers have achieved in their maritime works.

The grinding of clinker at the Darsy works is entirely by millstones, and the fineness is determined by bolting the ground powder. The entire works are very ingeniously arranged with many clever devices which show Mr. Lavocat to be an accomplished engineer.

Works of E. Candlot et Cie., at Dennemont.

These works are new, having been built in 1893. They also develop a new cement industry, no works having been previously built in this vicinity. The conception of the enterprise is due to Mr. Edouard Candlot, the well-known French engineer and author, who had previously been for years the director of the works at Boulogne of the Société Anonyme des Ciments Francais, the company which owns the largest cement plant in France.

This new enterprise is on the left bank of the Seine and about an hour's ride by express train from Paris by the Western Railroad. The works at Dennemont are quite unique in plan. They are interesting not only as being the newest works in France, but because they represent the ideas of Mr. Candlot in developing a plant to suit local conditions. The property is situated on the Seine, and the river is the source of supply for fuel and the shipping outlet of the works. From the river there is a plateau of about 1,000 feet to the foot of the hill, and it is here at the base of the hill that the works have been built. At

first sight this appears awkward, but after examining the plant it is found to provide a convenient and economical plan for construction, and to be quite economical in manual labor in operation. The raw material (chalk) is quarried in tunnels running directly into the hillside opposite to and a little above the level of the wash mills. Thus the cars run by gravity to the wash mills and the slurry runs by gravity to the *bassins de dosage;* thence is pumped directly through a height of 100 feet to the settling basins on the top of the bluff. This is the only operation in which gravity is adverse, and it is cheaply performed by power. The settling basins are high enough above the kilns to permit thick slurry to run into the drying chambers. In burning, the clinker passes from the top of the kilns to the bottom, and the outlet at the bottom is at a little elevation above the crushing machinery. Still a little lower down is the upper floor of the mill building, and still below the mill building is the storehouse for the ground cement. Thus, after the slurry is pumped to the top of the hill, the course of the material is regularly downward, with gravity to assist each operation.

The coal, of course, has to be carried to the top of the kilns, as in all other works. This is done by a cable-way leading from the river to the top of the hillside. At the river side for handling the coal and for loading the cement is an electric locomotive jib crane. The whole scheme is ingeniously worked out, and the product of the works is evidently unusually large for the manual labor employed. The kilns at the Dennemont plant are continuous kilns of the same type described above for the Darsy plant, a little more modern and a little simpler in design, but essentially the same; and the process of handling the materials and determining the *dosage* is exactly the same, and hence need not be further described.

Mr. Candlot is a firm believer in what the French call *ciment armé;* that is, cement work built on an iron skeleton of wire, expanded metal or other device of this kind. The floors of the buildings are sustained by beams and flooring of this *ciment armé,* and the hoppers bringing the clinker to the mills are also built of it. Also the hoods in the laboratory, and even the slabs which cover the lower drying chambers of the kilns are made of it. All of it is in excellent condition, though the mills are doing service under very heavy loads.

At the Dennemont works there are usually three inspectors representing the Ponts et Chaussées and the city of Paris. The output of the works is about 120,000 barrels per annum and is largely consumed by the city of Paris, which is its natural market.

As showing the quality of the French Portland cements, the following reports will be of interest:

Portland cement made by Messrs. Darsy, Lefebvre & Lavocat. Tests by Feret at Boulogne.

Setting Time.—Initial set, 3 degrees, 20 minutes; final set, 9 degrees.

Fineness.—Two per cent. residue on sieve of 5,850 meshes per square inch; 22 per cent. residue on sieve of 32,500 meshes per square inch.

Tensile Tests.—Seven day neat, 550 pounds; 28 day neat, 730 pounds; 7 day, 1 to 3 sand, 270 pounds; 28 day, 1 to 3 sand, 385 pounds.

Chemical Analysis.—Silica, 22.15 per cent.; alumina, 8.20 per cent.; oxide of iron, 2.50 per cent.; lime, 63.60 per cent.; magnesia, 0.85 per cent.; sulphuric acid, 1.20 per cent.; loss in calcination and undetermined, 1.50 per cent.

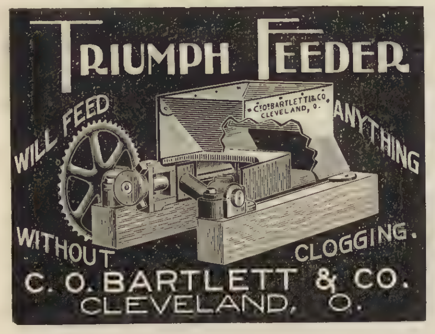
Portland cement made by Messrs. E. Candlot & Cie.

Setting Time—Initial set, 1 degree 40 minutes; final set, 3 degrees 0 minute.

Tensile Strength.

	2 days. Lbs.	7 days. Lbs.	28 days. Lbs.	84 days. Lbs.	6 mons. Lbs.
Neat cement	384	669	752	757	707
1 cement to 2 sand	296	498	553	589	610
1 cement to 3 sand	232	373	437	447	481
1 cement to 5 sand	112	202	236	267	301

Chemical analysis.—Silica, 21.70 per cent.; alumina, 8.00 per cent.; peroxide of iron, 2.60 per cent.; lime, 63.85 per cent.; magnesia, 0.72 per cent.; sulphuric acid, 0.60 per cent.; loss in calcination, 2.30 per cent.; elements undetermined, 0.23 per cent.



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Yours very truly, CASTALIA PORTLAND CEMENT CO.,

W. J. Prentice, President.

Duplicate.

C. O. BARTLETT & CO., Cleveland, Ohio.

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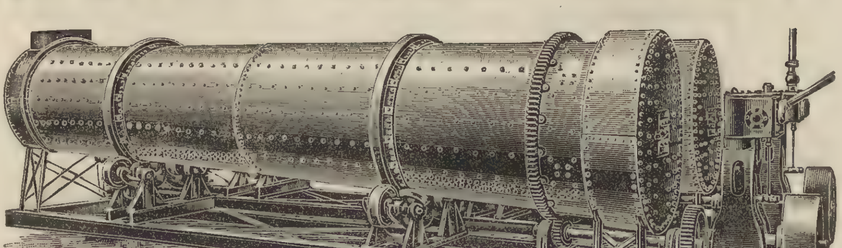

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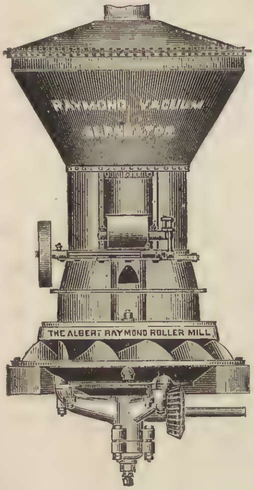

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Speed, 100 Revolutions Per Minute.

Everything fed into the mill is reduced to the required fineness without tailings or waste.

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Mr. A. RAYMOND, 1402 Monadnock Building, Chicago, Ills.

Dear Sir—The Albert Raymond Roller Mill we purchased of you last August, and installed on the third floor of our factory, has given the most perfect satisfaction in grinding our various kinds of materials. We have thoroughly tested same and can state for a certainty that it will grind more material per hour, with less power, and grind it finer, than any machine we have ever tried before or seen in operation ; and there does not seem to be any material wear on the roller tires and ring.

We are running the mill 100 revolutions per minute, and when grinding marble it turns out 5,660 lbs. per hour for an average day's run, the finished product being 150 mesh fine. We think the manner in which you support the rollers far superior to a pendulum suspended roll, as formerly constructed in all other roller mills ; also that it accounts for the great grinding capacity, and the easy running of the mill. We feel sure you will have great success in introducing same.

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J. B. KING & CO.

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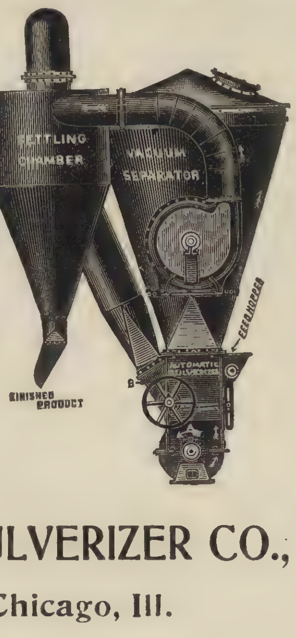
Yours truly,
THE VULCANITE PAVING COMPANY,
W. H. LOBER, General Superintendent.



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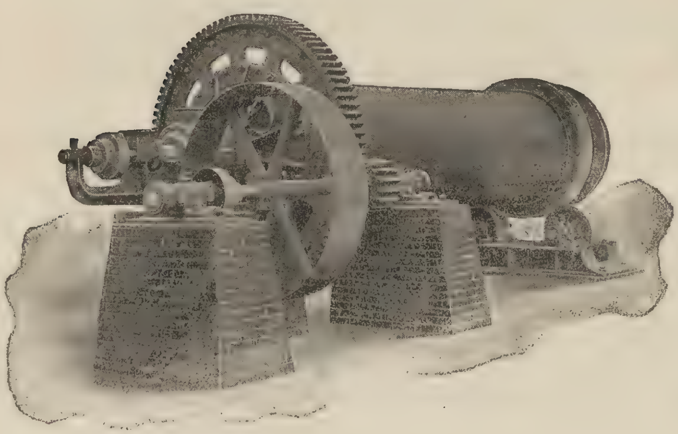

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